TL 230
.A93

Automotive service digest

MOTOR TRUCK MANUAL

A Practical Book of Instruction on the Construction and Care of Motor Trucks

94 Illustrations

BY THE EDITORIAL STAFF
OF THE
AMERICAN AUTOMOBILE DIGEST

CINCINNATI
AMERICAN AUTOMOBILE DIGEST
1921

TL230
.A93

Copyright, 1921, Edward S. Rosenthal.

FEB 28 1921

©Cl.A608494

CONTENTS.

PAGE

PREFACE 5

INTRODUCTION 7

CHAPTER I.

Chassis Layout 9

CHAPTER II.

Motor Truck Engines 18

CHAPTER III.

Radiators and Cooling System 40

CHAPTER IV.

The Transmission and Clutch 49

CHAPTER V.

Axles and Final Drive 63

CHAPTER VI.

Universal Joints and Drive Shafts 86

CHAPTER VII.

The Steering Gear and Steering Linkage 98

CHAPTER VIII.

Springs 108

CHAPTER IX.

Wheels, Rims and Tires 119

CHAPTER X.

Muffler and Cutout 128

CHAPTER XI.

Motor Truck Governors 135

CHAPTER XII.

Motor Truck Bodies 142

PREFACE.

THE horse has become unprofitable, as he is costly to buy and expensive to keep. To quote Thomas Edison, who has said, "A horse is the poorest motor ever built," he eats 12,000 pounds of food a year, the output of five acres, and yet he is only two per cent efficient. A recent Government report shows that a farm horse averages only 3½ hours of work per day, and requires at least 3,000 cubic feet of space for himself and his feed.

The above answers "Why the motor truck?" It is undoubtedly the most economical and efficient means of transportation. In the succeeding chapters, we will endeavor to illustrate and explain the construction of these vehicles and their advantages. In order to simplify the treatise the various units have been classified in groups. With the limited amount of space available for so large a subject, it is not possible to cover all types of vehicles, so this work is limited to the motor truck which is propelled by an internal combustion engine. The information compiled in this volume should enable the lay mind to derive a thorough idea of the construction of vehicles intended for commercial purposes, and if this is accomplished, then the appearance of this volume will be appreciated and the authors will have accomplished their purpose.

EDITORIAL STAFF,
THE AMERICAN AUTOMOBILE DIGEST.

INTRODUCTION.

WHEN self-propelled road vehicles were first introduced they attracted very little public attention, and by many were considered as impossibilities. However, time has proven that the commercial vehicle has by far exceeded the fondest hopes of its loyal supporters of the early days, and today the motor truck industry is progressing rapidly. In a few years the production of trucks will exceed that of passenger vehicles, for the commercial vehicle is a paying proposition to any business, regardless of its nature.

In any business, the most vital factor is rapid, efficient and economical transportation of product. The motor truck solves this problem; in fact, its economical features are so great that most business men wonder how they have managed to get along without them. There never was a time in the history of the world when time was so valuable as it is today, or when the value of time was so thoroughly appreciated. The necessity of saving time—of doing more each day—resulted in the discard of the oxcart for the horse and wagon nearly a century ago.

With the development of the motor truck, with its untiring speed and greater load capacity, the past fifteen years have seen a gradual replacement of horse-drawn vehicles by motor trucks, until today the motor truck is the standard of efficiency in every kind of haulage work. The remarkable performance of the motor truck in the past war has won for it a permanent place in the commerce of the world. In addition to

the development of the industry, the war has revealed to a prosperous world its wonderful possibilities. In many localities it has entirely displaced the horse-drawn vehicles and is holding its own with the express companies, and only recently has proved its ability to compete with the railroads. The time will come when it will surpass in importance all other forms of transportation.

Today the motor truck stands as a dependable, efficient machine that the wide-awake, progressive merchant or manufacturer, with transportation problems ever before him, cannot afford to disregard. While many conflicting theories of design and details of construction still exist, which is only natural when development is somewhat hindered by efforts to build to a price rather than to a standard of quality—in the long run the latter policy will produce the lowest cost per ton mile. For, behind the proper truck performance must be the mechanical construction, so necessary to provide continued service under the most severe conditions. Units best adapted for a specific purpose, properly made and properly combined, must be used.

In compiling this volume, the authors have endeavored to cover the mechanical construction of this type of vehicle in such manner as to provide a treatise that will enable the lay mind to grasp the theories which have been combined in the modern commercial vehicle.

CHAPTER I.

Chassis Layout.

MOTOR TRUCKS may be classified according to the type of power plant used, as steam, electric, gasoline and gasoline-electric, and subdivided into two or four-wheel drive. Motor trucks propelled by internal combustion engines, using gasoline, kerosene or distillate, are almost exclusively used, and for this reason this text will be confined to this type of vehicle, since this will be considered as the accepted standard. Any vehicle conforming to this accepted standard may be divided into two parts—the chassis and the body. The chassis—or running-gear, as it is sometimes called—consists of the frame, power plant, springs, axles, steering gear, wheels, tires, etc. The body is considered as the structure which carries the pay load and forms the driver's cab. These are usually built on sills and form a unit which is attached to the frame of the vehicle.

The general layout of the chassis covers such points as the location of the driver's seat or cab in relation to the location of the power plant, which controls the distribution of the useful or pay load of the vehicle. This affects the over-all length and turning radius of the vehicle.

The principal problem which had to be solved by the commercial vehicle designer was how to make use of the over-all length of the chassis to best advantage, bearing in mind accessability and all other factors entering into this problem. Frame construction, which is generally consid-

ered as the foundation of the vehicle, also had to be solved.

In the early stages of the industry a number of designs were evolved, each of which possessed advantages, advocates of each design had a number of arguments for a particular construction. A period of evolution was finally passed resulting in three types of power plant mounting, as follows:

Engine located under a hood in front of the driver's seat.

Engine located under driver's seat.

Engine located at side of driver's seat.

Most designers have selected the first combination, since it possesses some very desirable advantages, which are difficult to obtain with the other combinations. The accepted standard being typical of current passenger car design and possessing all the advantages of the latter. This construction necessitates making the total overall length of the machine somewhat greater than it would be for the same capacity with the second or third arrangement.

A perspective view of the trend of commercial car construction is depicted in Fig. 1. It will be noted that the engine is carried under a removable hood in front of the driver's seat and control elements. This design permits of easy access to the engine and accessory parts from both sides and top, making it equal in point of accessibility to passenger cars. The driver's seat is also accessible, while the clutch and transmission can be easily reached through the floor-board opening, where they form a unit with the motor. The greater percentage of the paying load is concentrated on the rear axle or driving wheels, resulting in good traction and easy steering. In addition, this construction results in a pleasing ap-

pearance, which is of some advantage in smaller vehicles, being used to some extent as an advertising feature.

Engine accessibility merits more attention than any other feature of the motor truck. The importance of this will be admitted by anyone having had experience in the operation of an internal combustion engine. The day is still far distant when a gasoline engine may be locked in a box, and, with a supply of essence, be expected to motor satisfactorily until, like the justly famous story, its multitudinous parts give out simultaneously as a result of legitimate wear. The desirability of compact arrangement will be endorsed as a purely academic proposition and will be heartily subscribed to as a thoroughly practical feature by truck operators.

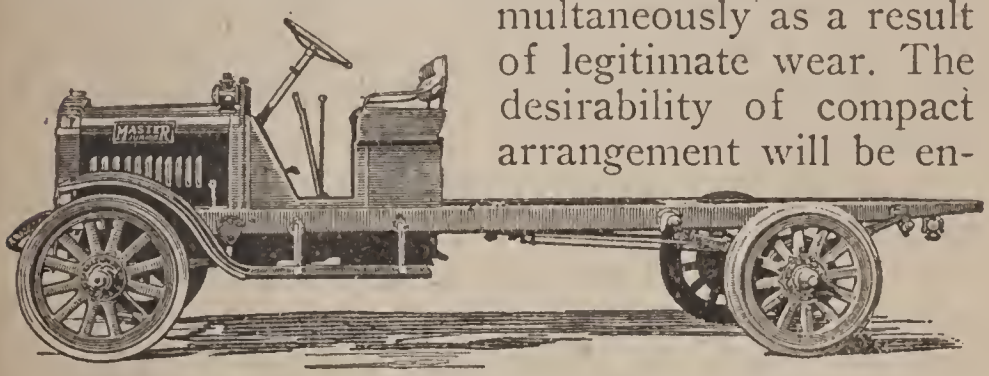

Fig. 1.—Conventional type of truck chassis.

Frame Construction.

The chassis frame, as previously mentioned, practically forms the foundation of a vehicle, since all the power-transmitting and other units are attached to it, and it is frequently referred to as the back-bone of a motor truck. Its construction depends, to a considerable extent, upon the general scheme of the chassis layout, the construction of the power-transmitting units and their mounting, as well as the method of final drive, wheel base, capacity, etc.

In most of the early designs little attention to the frame, as other units such as the power plant, axles, etc., were deemed of greater importance, hence the frame received slight consideration. However, difficulties soon arose due to failure, accidents, etc., which were traced directly to poor frame construction. The result being, the discovery that frames could be built with greater strength and less weight if the problem was given proper consideration.

Motor truck frames are of two types, the pressed steel type and the structural channel type. These may again be divided into various subtypes, depending upon the general construction and material, as well as the distribution of the main units.

The pressed steel frame is by far the most popular and is used on vehicles of all capacities. The structural channel is still used by some makers, however, this type is slowly being replaced. This is due to the fact that the pressed steel frame is much lighter than the structural channel for equal strength, and, while the first cost varies with its design, it very rarely becomes more expensive than the latter type. The straight side rail is the cheapest construction and incidentally provides the maximum strength. Bumper and cross members are formed to meet the general requirements of the layout and are universally riveted to the side rails.

Frames of either type of material may be made rigid or flexible and, while both kinds of material are subject to heat treatment, it is generally conceded that pressed steel is a higher-grade metal than rolled stock. Owing to its temper it will stand a certain amount of bending, which would give the rolled stock a permanent set or crack it.

Fig. 2 illustrates a pressed steel frame for a two-ton vehicle. The side rails are tapered at the front and rear, while the flange width is greatest at the point where the maximum stress

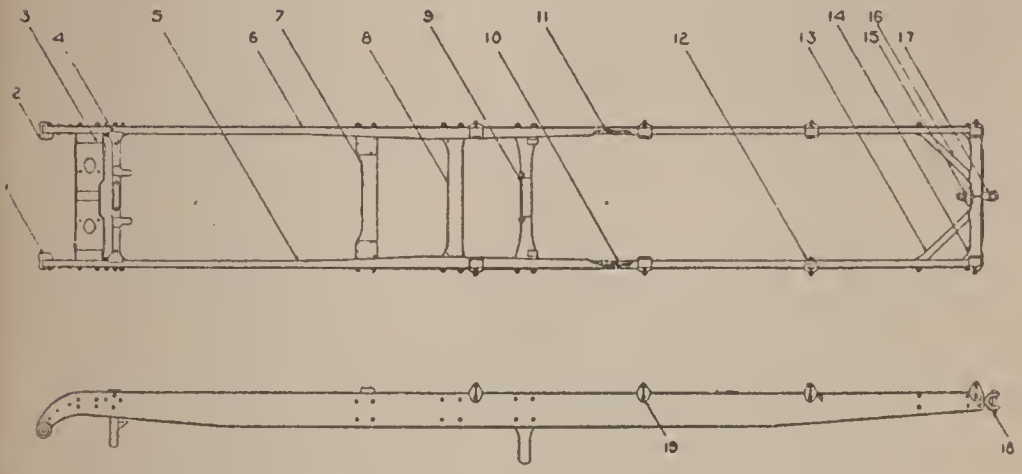

Fig. 2.—Pressed steel frame for heavy duty trucks.

acts. Six cross members are used which, in addition to supporting the various units, greatly stiffen the frame laterally.

Fig. 3 illustrates the construction of the various cross members which are used in pressed steel frames. The forward or dropped member has integral gussets and is used to support the radiator and in some cases the front end of the power plant. The rear cross member also has integral gussets, while the center members are inverted and riveted to the side rails of the frame.

Fig. 3.—Conventional type of cross members used in pressed steel frames.

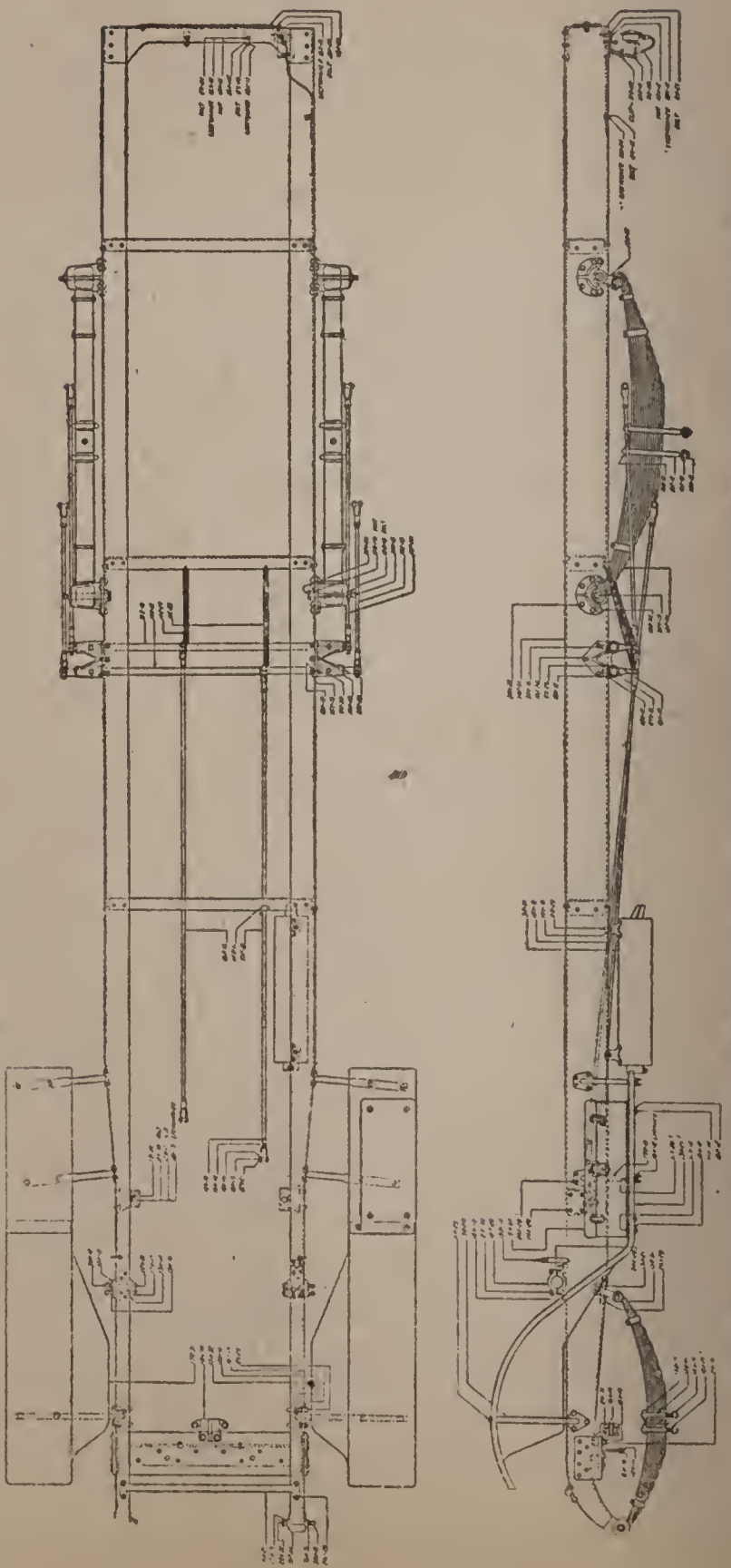

Fig. 4.—Chassis frame assembly, showing mounting of springs and various minor parts.

Fig. 4 illustrates the general layout of a 3½-ton frame, and shows the method of attaching the springs, running-boards, fenders, etc. It also illustrates the general arrangement of the brake control mechanism or linkage. The side rails are tapered at the front end to provide a greater turning radius, as a vehicle of this capacity would have quite a long wheel base. The front springs are mounted under the side rails, while the rear are mounted outside to provide the

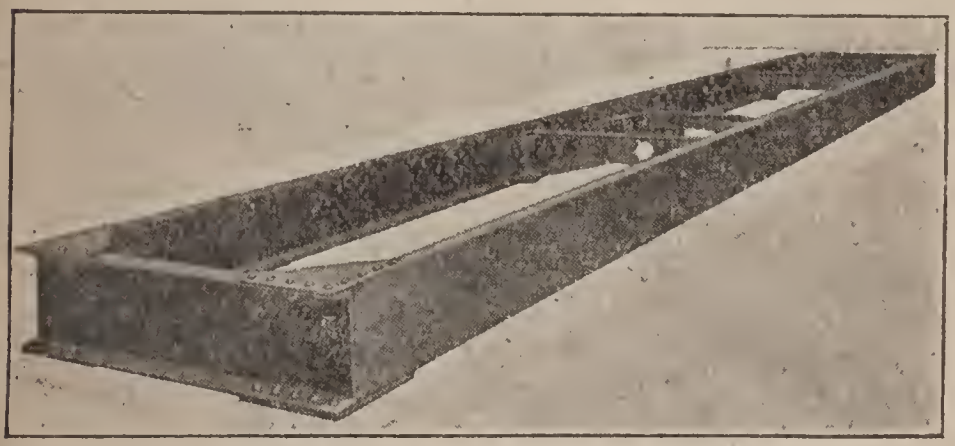

Fig. 5.—Structural or rolled channel type of frame for a heavy duty truck.

maximum spring center on the axle, since this controls to considerable extent the carrying capacity of the rear axle.

Fig. 5 illustrates the rolled channel type of frame, combined with rolled channel and cast cross members. Separate gusset plates, made from boiler plates, are used as braces for the rolled channel members, while the cast members have integral gusset plates.

In order to eliminate the possibility of breaking of frames there is a general movement against drilling holes in the flanges of the side rails. Instead of drilling these flanges for attaching the body, etc., brackets are supplied

which are attached to the vertical web of the side rail.

Structural or rolled channel is bought from the steel mills in stock lengths. It is usually manufactured from Bessemer steel, afterwards subjected to the open hearth process, in which it is saturated with carbon, to certain specifications for certain uses. This material is very extensively used in the construction of buildings, bridges, etc.

Pressed steel is purchased in sheet form, cut to the proper shape in the flat and then pressed into channel form under great pressure. It is made of steel rolled into sheets, is somewhat closer grained and more readily formed. It also permits of greater simplicity in assembling, since parts can easily be belted or riveted to it.

Types of Drive.

In the conventional type of design the power of the motor is transmitted to the rear axle from which it is converted into useful work at the rear wheels. There are a variety of methods of accomplishing this, which will be covered in the chapters which follow. There are also a number of motor trucks which are driven through four wheels. This latter type has gained considerable popularity of late, perhaps due to conditions under which a motor vehicle must propel itself to any point that a horse-drawn vehicle can reach. This is especially true where departure from the road surface is necessary as in building roads, entering excavations, handling coal, etc. Fig. 1 illustrates the conventional type of rear wheel driven chassis, while Fig. 6 illustrates a four-wheel drive chassis.

Care of Chassis Frame.

Very little need be said regarding the chassis frame, since it requires very little attention. Occasionally all bolts and rivets should be inspected to see that they are tight and cannot rattle loose. Metal will rust quickly and the chassis frame is not an exception, as it becomes essential to keep it covered with a good coat of paint to retard the accumulation of rust.

Fig. 6.—A four-wheel drive chassis.

CHAPTER II.

Motor Truck Engines.

Cycle of operations, construction, lubrication and care.

THE four-cycle, four-cylinder engine is universally employed as the source of power for motor trucks. This type of motor consists essentially of a row of four upright cylinders in which the charge is ignited and permittel to expand. This expansion of the gases acts upon pistons arranged to move up and down within the cylinders. These pistons are connected to the crankshaft by connecting rods and, through the reciprocating movement of the pistons, cause the crankshaft to rotate. At its rear end the crankshaft carries a heavy flywheel which steadies and equalizes the motion of the turning mechanism. At its front end a hand crank is used to revolve the crankshaft and other moving parts for the purpose of starting the engine. The crankcase, supported from the frame of the truck, forms a housing which encloses the crankshaft and various working parts, and also supports the cylinders. In addition, it also acts as a reservoir to carry a supply of lubricating oil for the motor.

At their upper ends, each of the cylinders have two openings, closed by poppet valves. One of these connects with the exhaust system and the other with the intake manifold and carburetor. These valves are opened and closed at proper intervals by pushrods, which are actuated by the camshaft located in the crankcase and driven

by gears from the crankshaft. This shaft runs at half the crankshaft speed, with the result that each valve is opened and closed once during every two revolutions of the crankshaft.

A spark plug, projecting into the combustion space of the cylinder, serves to electrically ignite the gas at the proper instant. This current, used for ignition purposes, being generated by a magneto driven by the engine in proper relationship.

A double wall or water jacket entirely surrounds the upper part of the cylinders, and a circulation of water is constantly maintained between the two walls. The function of the cooling system, and the construction of the various units, are covered in a separate chapter.

How the Motor Operates.

The power of the motor is produced by the expansion of the gases within the cylinder, above the pistons,—this expansion forcing the pistons downward and turning the crankshaft through its connection with the piston by the connecting rod. All truck-engines operate on the four-cycle or four-stroke principle. That is, a complete cycle of operations requires four piston strokes, or two revolutions of the crankshaft must occur for each power stroke. This can be more clearly understood by reference to Fig. 7, which shows the four strokes of the piston and may be described as follows:

1. When the piston starts down on the first stroke of the cycle, as in "A," the inlet valve opens. The motion of the piston tends to create a vacuum in the cylinder, and as it is in communication with the carburetor, it draws in a charge of fresh gas through the valve which re-

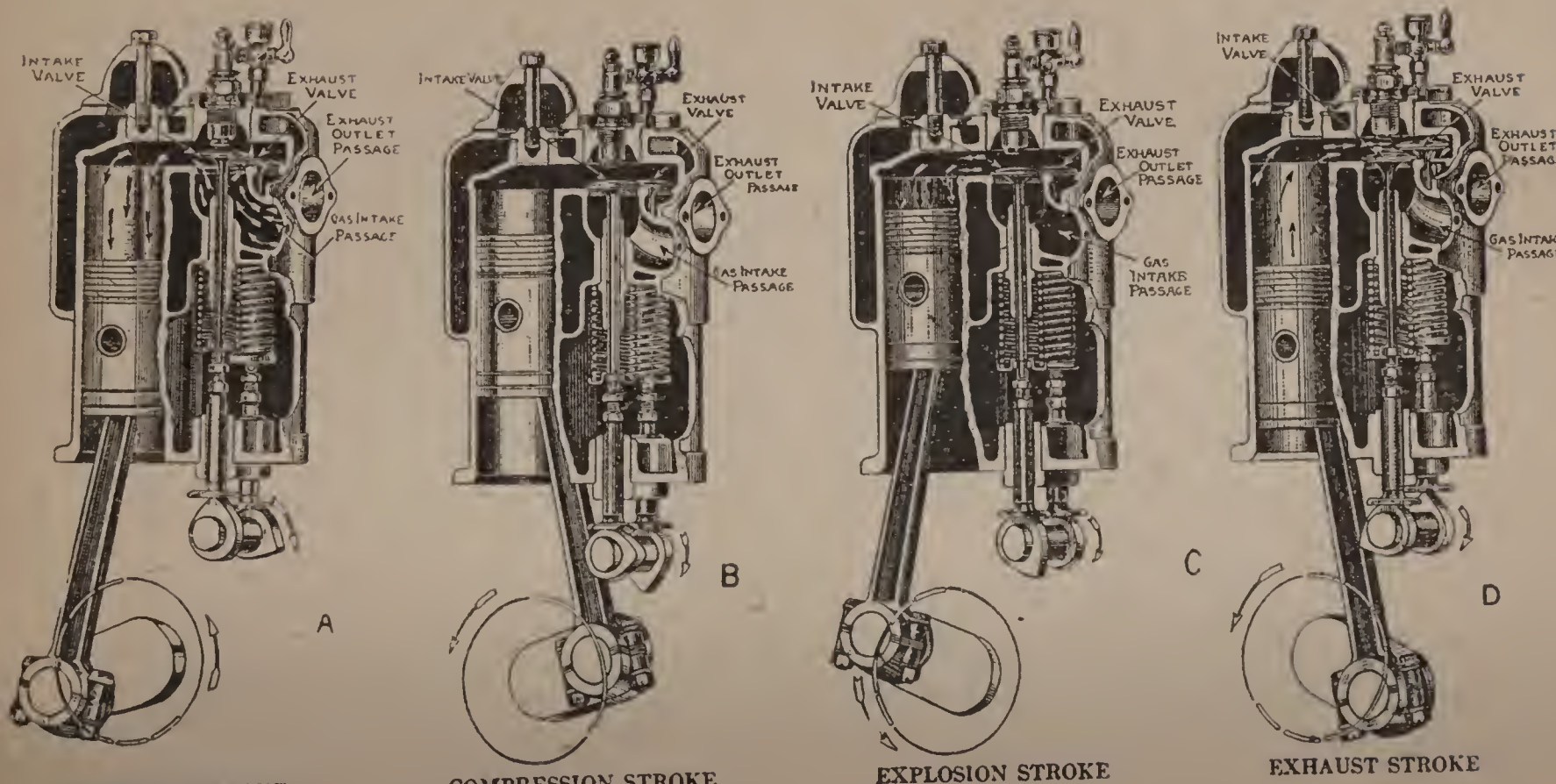

Fig. 7.—The cycle of operations of a motor truck engine.

mains open throughout the down stroke of the piston.

2. When the piston has reached the bottom of its stroke and starts up, as in "B," the intake valve closes and the piston continues on its upward stroke, compressing the gases which it had previously drawn in into a comparatively small space in the upper end of the cylinder.

3. When the piston reaches the upper end of its stroke as in "C," the gas which was compressed on this stroke is ignited, by means of an electrical spark, which is made to jump the spark plug electrodes within the cylinder. This ignition of the charge causes the gases to expand rapidly. This expansion forces the piston downward during the next, or working stroke, and the piston through its intermediate link, the connecting rod, imparts a turning movement to the crankshaft.

4. When the piston starts upward again as in "D," the exhaust valve opens and the rising piston pushes the remaining burnt gases out through the exhaust pipe, scavenging the cylinder, and thus having it ready for the next four strokes of the next cycle.

These four strokes, constituting the operations of all "four-cycle" engines, occur automatically in each cylinded with great rapidity, and always in the same order, thus: (1) Suction, down stroke of the piston, inlet valve open, exhaust valve closed. (2) Compression, up-stroke, both valves closed. (2) Ignition and expansion, down-stroke, both valves closed. (4) Exhaust, up-stroke, inlet valve closed, exhaust valve open.

It will be apparent from the above that only one stroke out of four, is a power stroke, but as the motor has four cylinders, of which each is on a different stroke at all times, the crankshaft

actually receives two power impulses at every revolution; this, in connection with a heavy flywheel, which smoothes out these impulses, making the flow of power practically continuous.

Engine Construction.

The details and the mechanism of a motor truck engine are shown in Fig. 8. The cylinders are usually cast in a single unit from grey iron, with integral water jackets, the latter being an important feature, as efficient cooling surface must be provided. The cylinder heads are generally made removable to provide access to various surfaces which require attention occasionally.

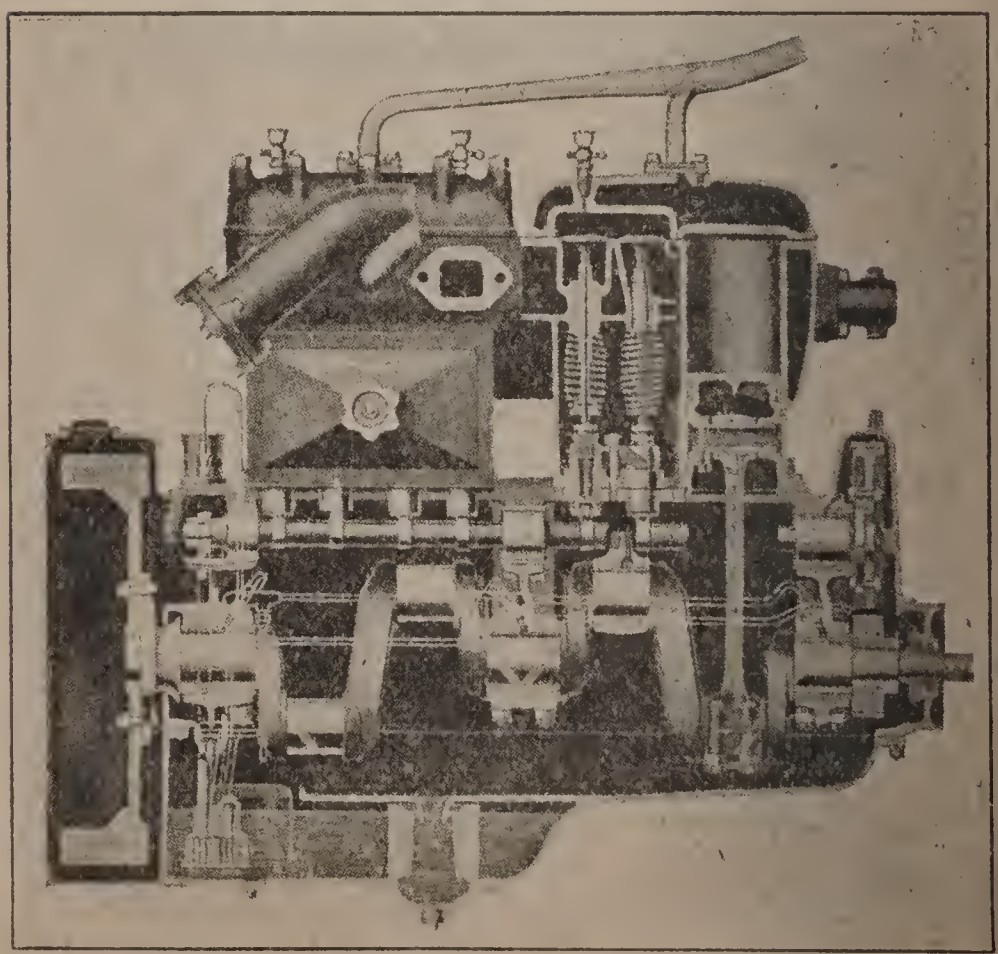

Fig. 8.—A photographic view, showing the details of construction of the conventional motor truck engine.

Figure 9 illustrates the conventional type of cylinder employed.

The pistons of the trunk type as illustrated in Fig. 10 are somewhat longer than the diameter of the cylinder. Near the center of the piston, bosses are formed which receive the piston pin, and near the top, grooves are formed which receive the piston rings. This illustration also shows the general construction of the connecting rod, crankshaft and flywheel.

The crankshaft is a horizontal steel shaft carried in journals, or bearings, inside the crankcase, while offsets corresponding to the number of cylinders are provided. These offsets are termed the crankpins, and carry the large end of the connecting rod and its bearings; it also carries the flywheel which is usually bolted to it.

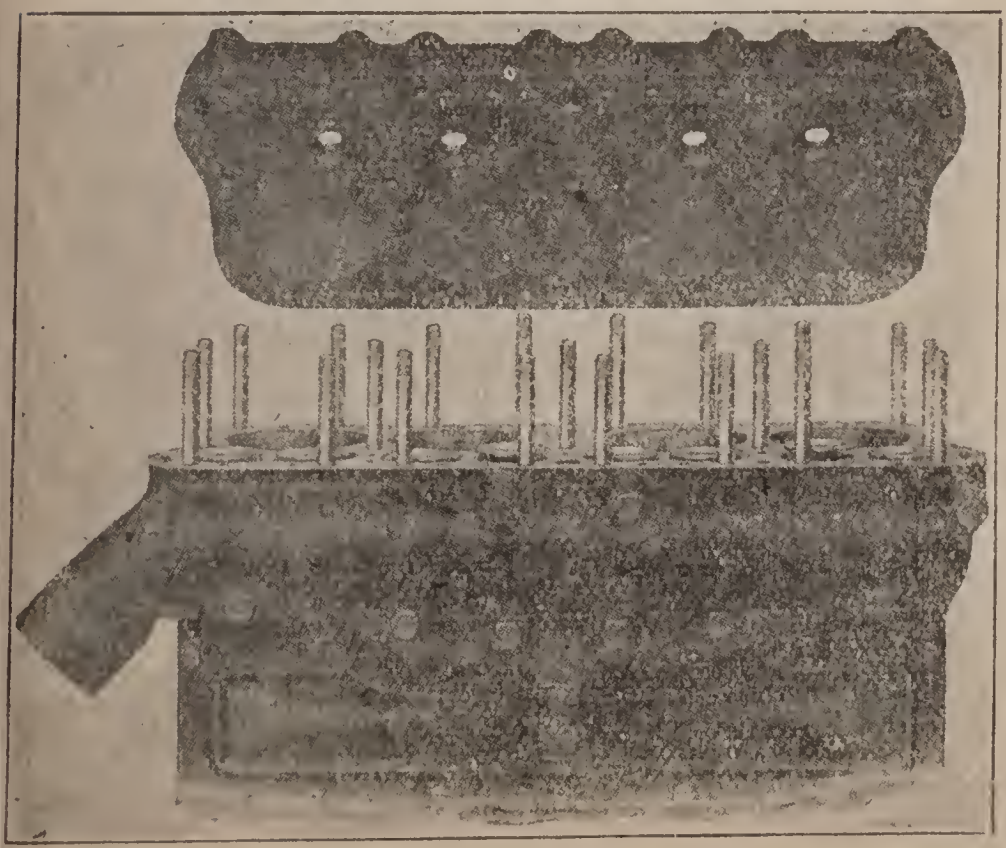

Fig. 9.—Conventional type of cylinder bloc with detachable head.

The connecting rod forms an intermediate link between the crankshaft and the piston. It is usually a drop forging, the small end carrying a bearing for the piston pin, while the large end is divided and carries the crank-pin bearing.

Figure 11 illustrates a cross-sectional view of an engine and clearly depicts the construction of the valve and valve operating mechanism. The camshaft is driven through gears from the crankshaft and opens the valves by means of cams, which are in communication with the valves through push rods. These cams are so spaced as to provide the proper sequence for the various valves in the cylinders. It is so driven in relation to the crankshaft that the valves open at the proper time. This cam merely opens the valve and holds it open for the proper period, while the valve spring closes it, through its pressure, which causes the valve stem to act in accord with

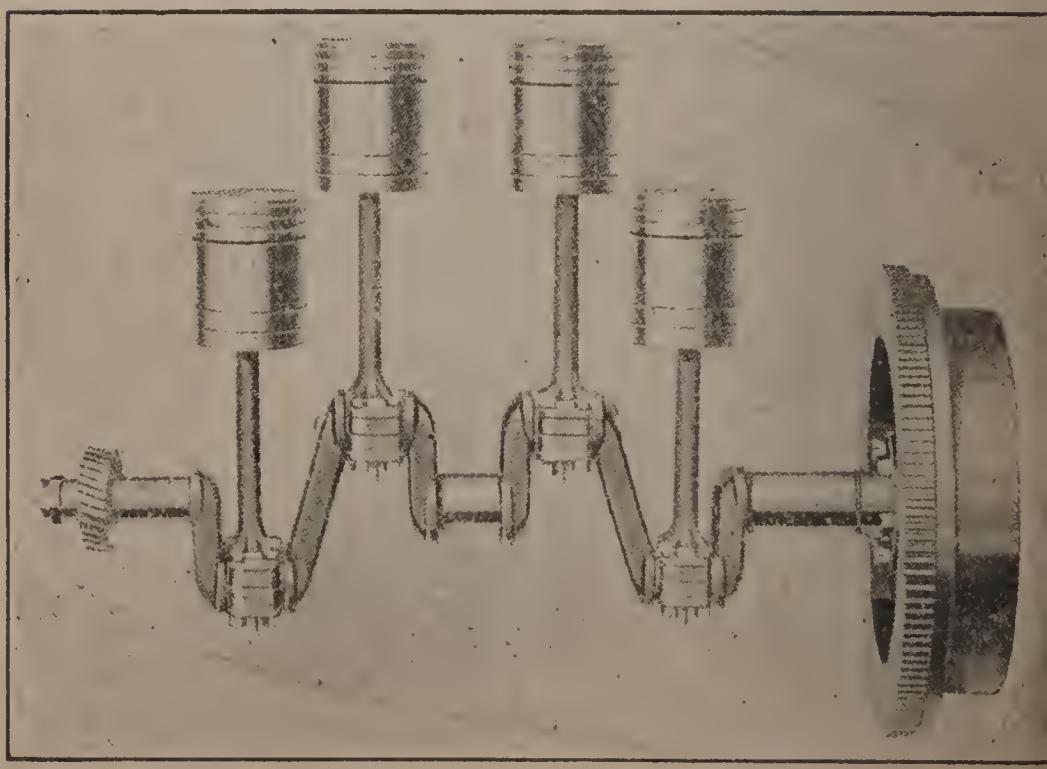

Fig. 10.—Piston, connecting rod, crankshaft and fly-wheel group.

the shape of the cam. The valve stems and push rods are enclosed and are provided with adjustment to compensate for wear as this sets in.

Engine Lubrication.

The purpose of the lubricating system is to provide a film of lubricant between all rubbing, moving, and bearing surfaces in order to prevent undue friction and wear on these surfaces. The crankshaft turns in bearings located in the crankcase and connecting rods and must at the same time resist the force created by the expansion of the gases on the pistons. Thus, if the rubbing surfaces were not separated by a film of oil, the bearings would become hot, cause excessive loss of power and finally seize on the journals. Therefore, the object of lubrication is to reduce the frictional losses to a minimum and carry away an excess heat which might react upon the bearing surfaces. A similar condition exists in the cylinders when the pistons are constantly moving up and down. A film of oil on the cylinder wall prevents undue

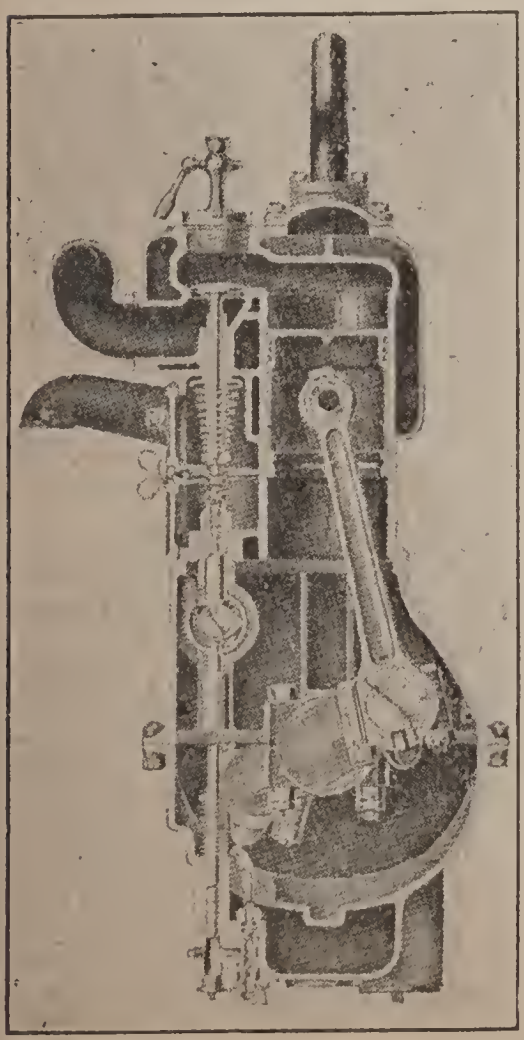

Fig. 11.—Illustrating valve and valve operating mechanism.

friction and excessive heating which might cause the pistons to stick. The methods of accomplishing this lubrication of bearing surfaces varies in the different engines. In some cases the oil is forced to the bearings under pressure, while in others it is forced to the more important bearings and distributed by means of a spray to the remainder. In some the spray is relied upon entirely to distribute the lubricant. These three systems are known as full force feed, combination force and splash feed, and splash feed systems.

The lower half of the crank case forms the oil reservoir and from here the lubricant is distributed by means of a pump. A filler tube is provided for replenishing the supply, while a tell-tale or pressure gauge is usually incorporated in the system to show that the lubricant is being circulated. All systems in use are of the circulating type; that is, the oil is circulated by some means to the bearing surfaces and the excess drains back to the reservoir, whence it is again recirculated.

In the splash system (Fig. 12), the connecting rod is provided with a dipper which sprays the oil to all bearing surfaces as illustrated. The crankcase is provided with oil troughs into which the connecting rods are dipped at each revolution of the crankshaft. The splash troughs are supplied with lubricant which is pumped from the reservoir. The excess oil drains back to the reservoir and is again recirculated.

Figure 13 illustrates the full force feed system. With this method oil is forced under pressure to every moving part that can be connected with the oil line. A gear pump is located in the lower half of the crank and is driven by gears from the

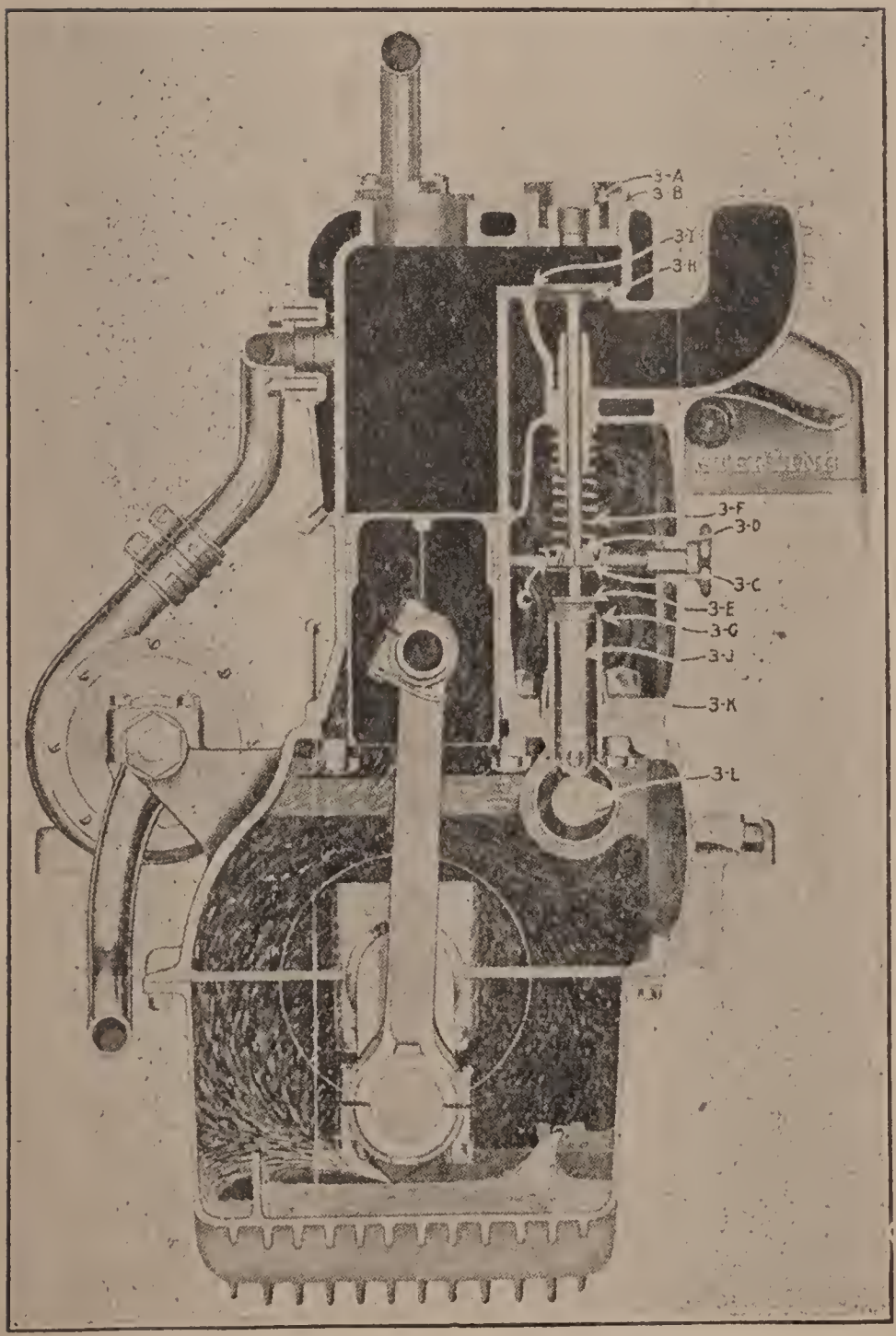

Fig. 12.—Splash system of lubrication.

camshaft. This pump forces oil through pipes which communicate with the main bearings, and from these bearings the oil is forced through a hollow crankshaft to the crankpin bearings, and thence through tubes fastened to the connecting rods to the piston pin bearings. The main oil pipe also communicates with the camshaft bearings, while the pistons and valve operating mechanism are lubricated by a spray of oil, which

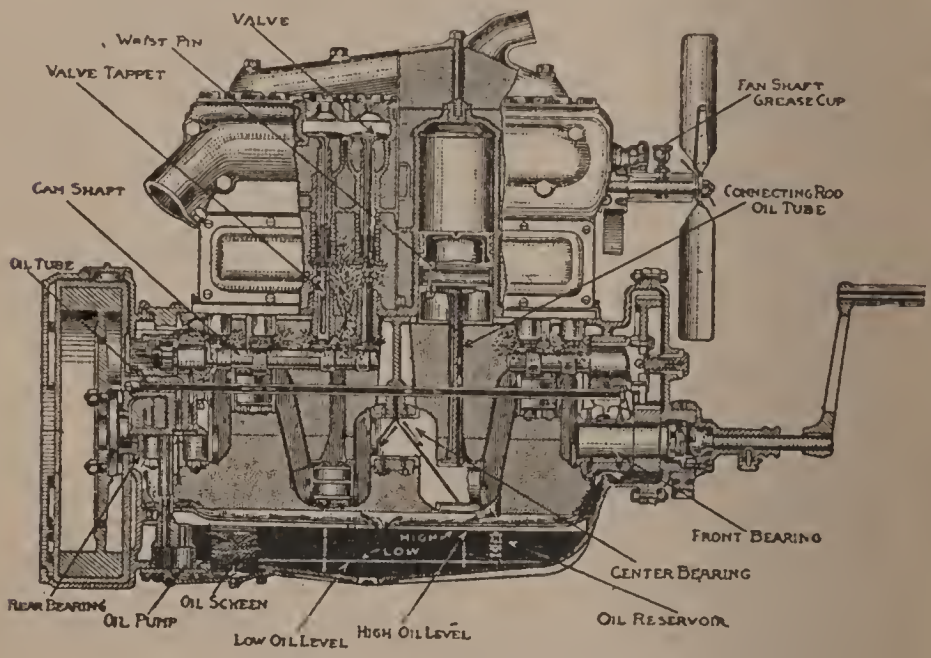

Fig. 13.—Full forced feed lubricating system.

works out of the bearings in the form of a fine mist. In this system the oil pressure in the system increases as the speed of the motor increases, thus increasing the supply as requirements demand.

The third system (Fig. 14) is a combination of the above types, oil being forced to the most important bearings, while the remaining bearing surfaces are lubricated by the spray escaping from the bearings which are lubricated under pressure.

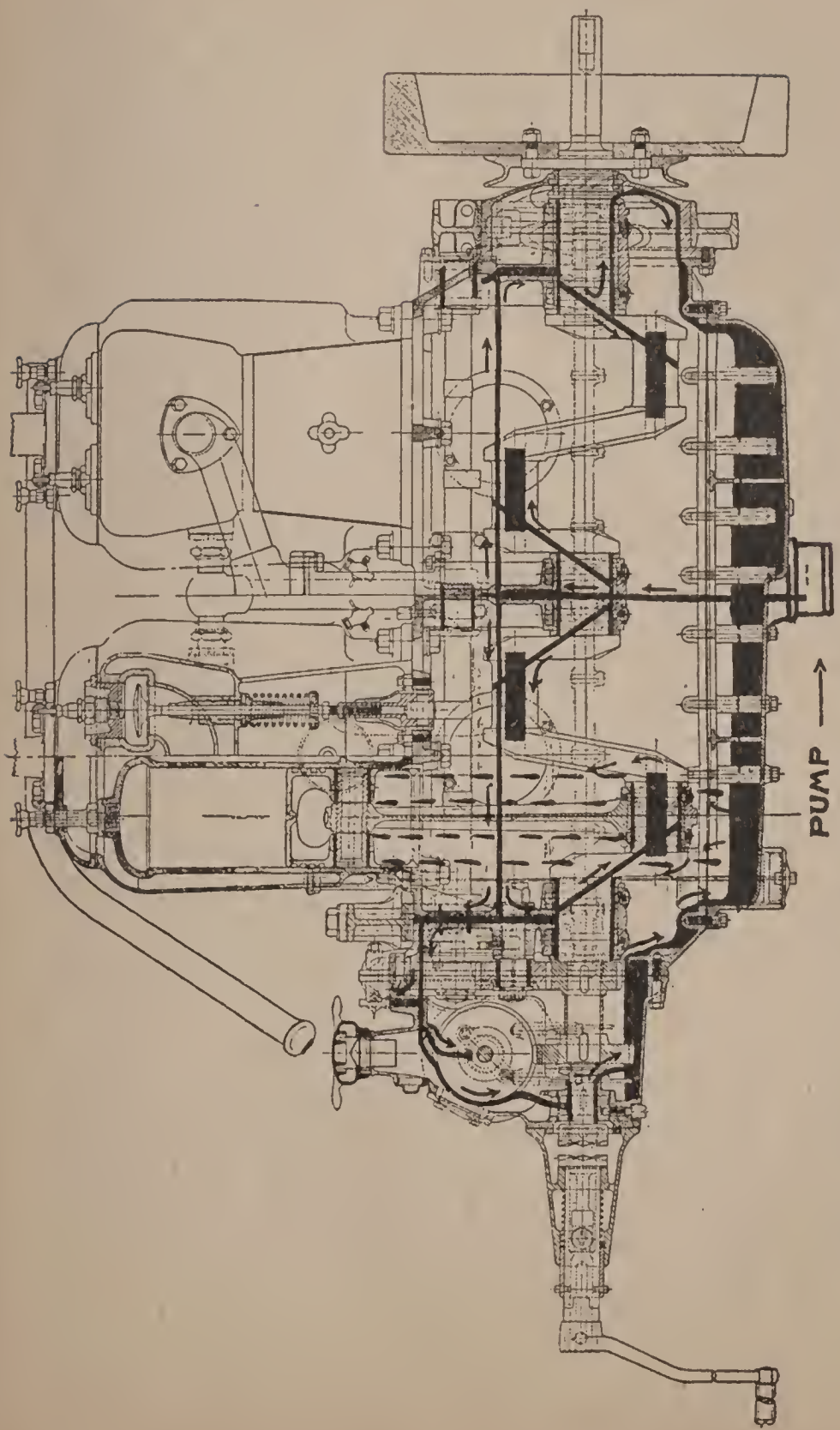

Fig. 14.—Combination splash and force feed. Heavy lines indicate path of lubricant.

Motor lubricating systems are highly developed and will properly lubricate, providing a sufficient supply of oil is maintained in the oil reservoir. The supply is usually limited, due to the small available space, and must be replenished daily.

Ignition Systems.

For ignition purposes both battery and magneto are used, the former generally being used when the engine is provided with an electrical starting system, and the vehicle with electric lights. In the battery system the storage battery is used as the source of current, while the magneto is a current generator in itself and requires no auxiliary source. The battery system consists, essentially, of a timer or circuit breaker and distributor, a coil, and a storage battery or set of dry cells. The current which has been previously transformed into energy in the battery, forms a path through the switch to the circuit breaker, which is built in a unit with the distributor. From the circuit breaker the current passes through the primary and secondary winding of the coil, thence through the distributor to the various spark plugs. The operation of the modern battery ignition may be described as follows:

Battery Ignition.

The current flowing from the battery is of low voltage and cannot bridge the spark plug electrodes within the cylinder, unless it is multiplied many times, in fact, several thousand times. This is accomplished by means of the circuit breaker and the coil, the latter being of the transformer type, provided with a primary and secondary winding. The current flows through the circuit breaker and tranformer coil primary winding and, as the circuit breaker breaks the

circuit of the primary, the current is multiplied many times through the secondary wiring which consists of many turns of fine wire. The primary circuit, which is composed of a few turns of heavy wire, is ordinarily closed upon itself. This causes a current to flow in it more or less proportional to the electromotor force. Now, at the time the circuit breaker opens, the current in it will almost instantly cease flowing. And as the circuit is opened so rapidly, and since there are a large number turns in the secondary winding, the electromotive force induced in the secondary winding will be many times greater and cause the spark to bridge the gap in the cylinder. Thus the secondary winding is used to transform the current to a high voltage. Figure 15 illustrates a wiring diagram for the battery system, as produced by the Atwater Kent Co. This shows in detail the path of the current, the heavy lines indicating the primary circuit and windings, while the light lines illustrate the secondary circuit and windings. This also shows the construction of the circuit breaker and the distributor, which are driven positively from the engine to provide the proper sequence of sparks within the cylinders.

Magneto Ignition.

There are two types of magneto ignition systems, the independent and dual types. This device is a current generator within itself and requires no auxiliary of any kind and incorporates all the elements of a complete ignition system except the spark plugs and switch. It generates the current, transforms it to a high pressure and distributes it to the spark plugs.

The structural portion of the magneto consists of permanent magnets of inverted U-shape—usu-

ally four are used. The free ends of these are termed poles, to which pole shoes of soft iron are attached. These magnets and pole shoes are mounted upon a non-metallic base, while the pole pieces are bored out cylindrically to receive the armature, which carries both the primary and secondary windings. The heavy or primary winding rotating between the pole shoes or magnetic field serves primarily to generate the current, and in connection with the fine or secondary winding, also serves to multiply the pressure or voltage, at the time that the primary circuit is broken to such an extent that it will produce a spark between the electrodes of the spark plug in the cylinder. Fig. 16 illustrates an internal circuit diagram of this system, while Fig. 17 illustrates the external wiring diagram, and shows its simplicity. The above covers the straight high tension or independent system. However, this system may also be combined with the battery system to form what is known as the dual type of ignition system, using one set of spark plugs, a two-point switch and a trans-

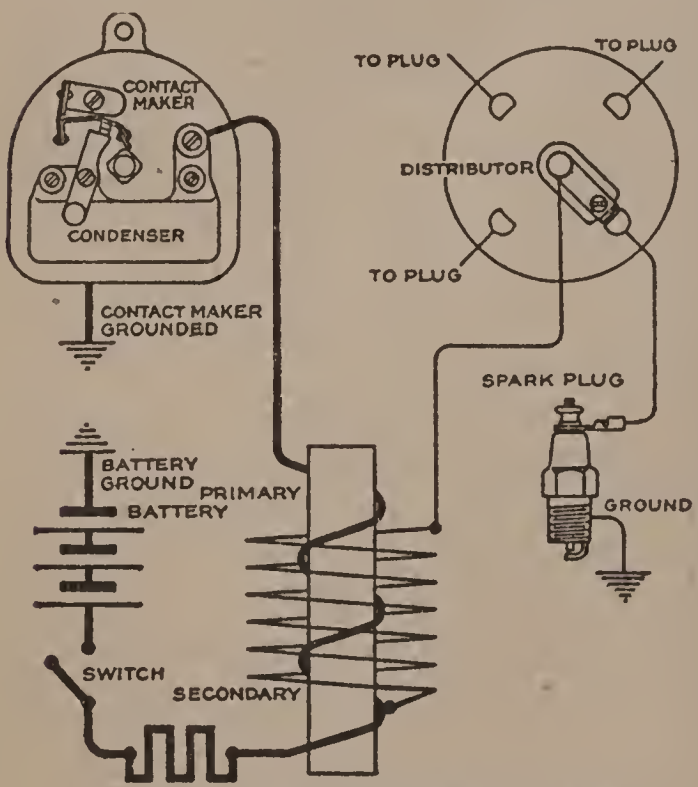

Fig. 15.—Circuit diagram of battery ignition system.

former coil. In this system the circuit breaker and distributor of the high tension magneto are also used for the battery system, which due to the low battery voltage, supplies a lower pressure current. In order to transform this low tension current to a high tension a separate transformer coil is provided. A wiring diagram for this type of ignition system is illustrated in Fig. 18. This system retains all the features of simplicity of the former and in addition provides an auxiliary system for starting purposes and emergencies.

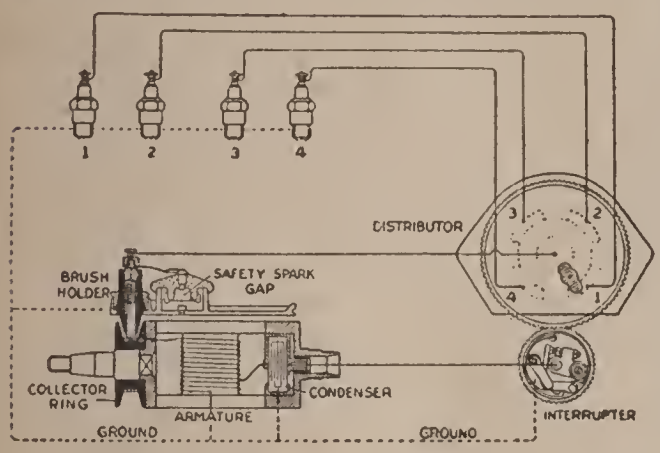

Fig. 16.—Circuit diagram of high tension magneto ignition system.

There is another type of magneto which in itself is a low tension instrument, since but one winding is provided on the armature, an external transformer coil being used to multiply the voltage of the current generated by the device to that required at the spark plug.

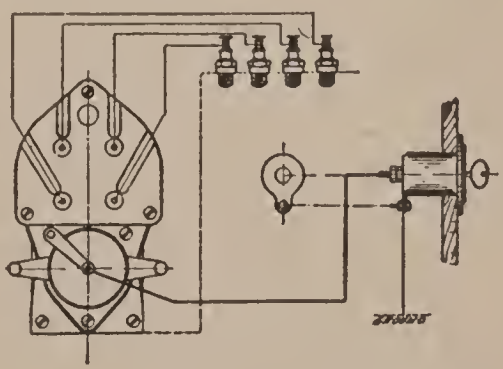

Fig. 17.—External wiring diagram of high tension magneto system.

Carburetors and Fuel Systems.

The carburetor is the device which measures the fuel charges for the motor and then mixes

them with the proper amount of air to form a combustible gas. It consists of a float chamber connected with the gasoline supply, a mixing chamber connected with the intake manifold, and the proper connection for supplying fuel and the control of the amount of fuel drawn into the engine. The latter being used to control the speed of the engine.

The majority of the modern types of carburetors are of the spray or nozzle type, in which a jet of atomized gasoline is sprayed from a nozzle into a current of air to form an explosion mixture. Figure 19 illustrates a prominent type. The gasoline is fed to a float chamber which is in communication with two nozzles, the one opening above the throttle valve being used for idling or low speed, while the one located in the mixing chamber is used for all other conditions.

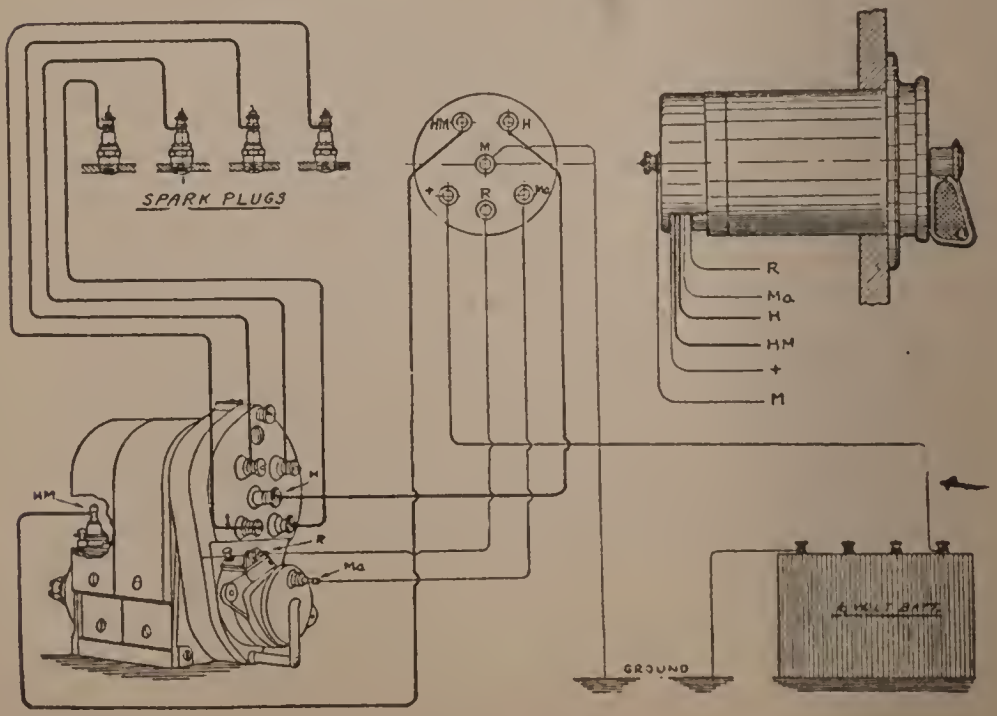

Fig. 18.—External wiring diagram, incorporating a high tension magneto, transformer coil and storage battery.

Gasoline is stored in a tank, usually located under the driver's seat, from which it is fed by gravity or other means, through a needle valve and strainer to the float chamber. This needle valve is regulated by a float, thus regulating the amount of fuel which can enter the chamber. At the top of this float small, weighted arms are pivoted, the ends of which rest idly on the top of the float. The function of this float and chamber is to maintain a constant level of gasoline in its own chamber and in the chamber in which the jet is located. This level must be constant so as to prevent the gasoline flooding over the jet, which would cause faulty running of the engine. As gasoline enters the chamber the float rises, and with it the weighted arms resting on it so that the needle valve is pushed down on its seat and shuts off the supply.

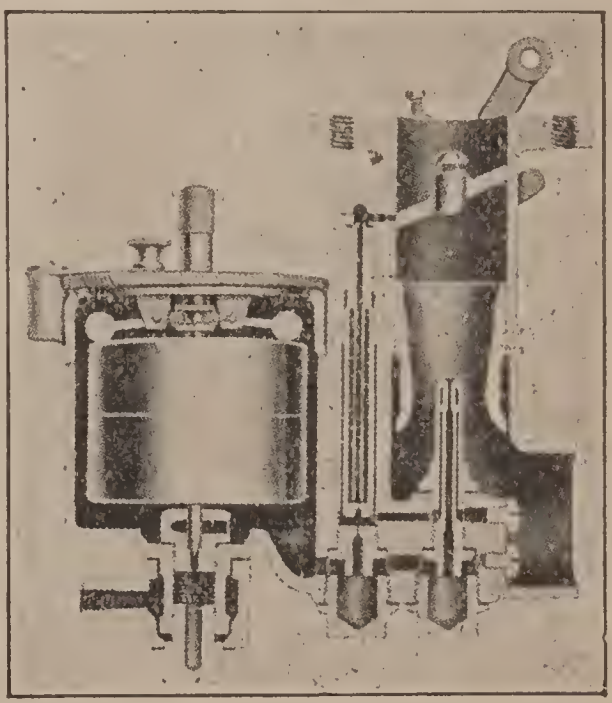

Fig. 19.—Sectional view of the conventional type of carburetor.

The other part of the carburetor is called the mixing chamber. This accommodates the jets and allows a stream of air to pass around it, when the suction of the piston acts upon the carburetor. When this air rushes up around this jet, it draws with it a certain amount of sprayed

fuel, and, when the mixture of sprayed fuel and air pass through the intake manifold, which is usually provided with some method of heating, it becomes a gaseous mixture and enters the engine in this state through the intake valve.

As previously mentioned, fuel may be fed to the carburetor by gravity or some other system. Gravity feed is used, however, in the majority of vehicles a more reliable system is used, due to the difficulties encountered in mounting the carburetor to provide a sufficient head of fuel. For the purpose of supplying a constant flow of fuel the vacuum system is now almost universally used. In order to illustrate this system and the method of carburetor control, Fig. 20 is presented herewith. It will be noted that the air drawn through the carburetor is taken through a pipe in close proximity of the exhaust manifold in order that it will be of the proper temperature. Gasoline is drawn from the main tank to the auxiliary tank by means of the vacuum created in the intake manifold and from the auxiliary tank it flows by gravity to the float chamber of the carburetor.

The operation of this vacuum tank (Fig. 21) may be briefly outlined as follows: This tank is divided into two chambers, the upper being the filling chamber and the lower the emptying chamber. The former contains a float valve and the connections to the intake manifold and the main fuel tank. The lower one has a connection leading to the carburetor. The lower chamber is always under atmospheric pressure, as the flow of gasoline from it is by gravity only. Atmospheric pressure being maintained in it by an air vent. The engine suction creates a vacuum in

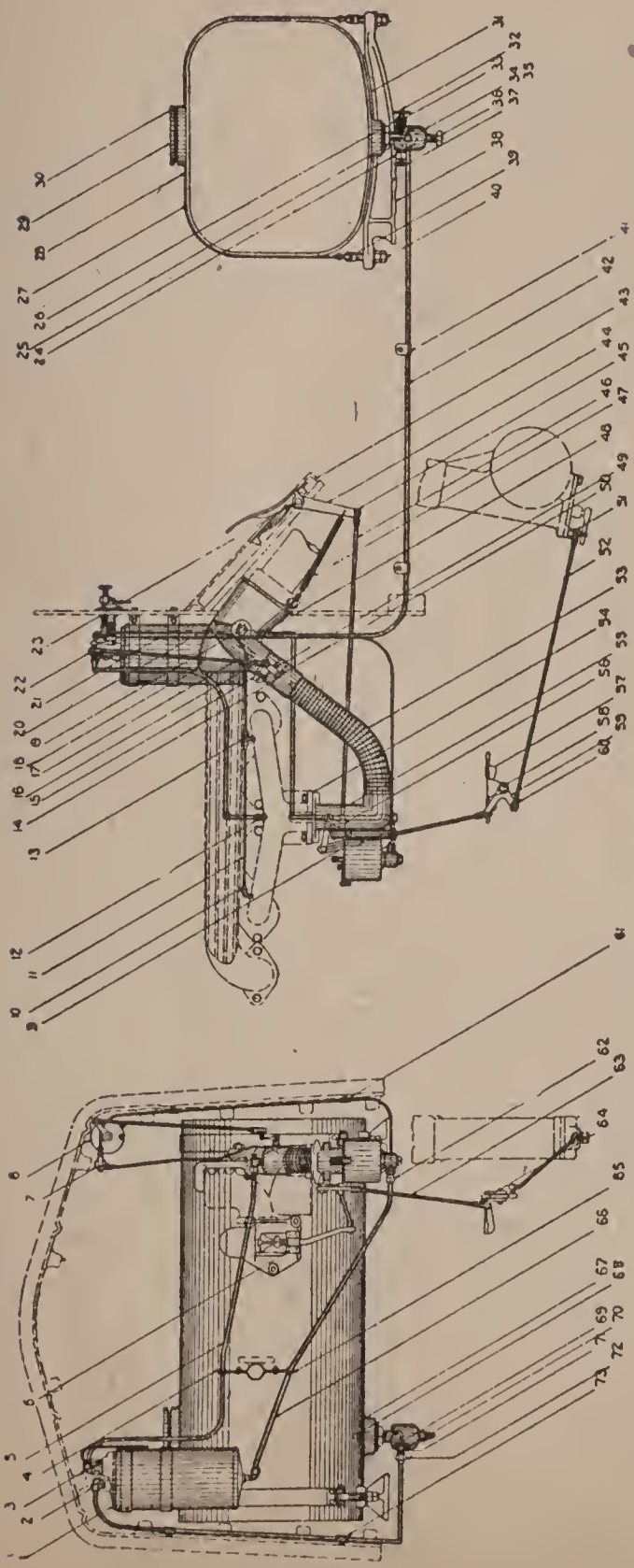

Fig. 20.—Fuel feed system, incorporating a vacuum tank.

the upper chamber, which closes a valve between the two chambers and in turn draws gasoline from the main tank. The gasoline as it is being drawn into the upper chamber operates a float valve. When this float valve has risen to a certain predetermined mark, it automatically shuts off the suction valve and opens an air valve. This open air valve creates an atmospheric condition in the upper chamber and gasoline immediately commences to flow to the emptying chamber. When the float is at the bottom of its chamber, the suction valve is open and the air valve closed. The lower chamber has a flap valve which prevents the fuel in the lower chamber from being drawn into the upper chamber, as the float falls and opens the suction valve.

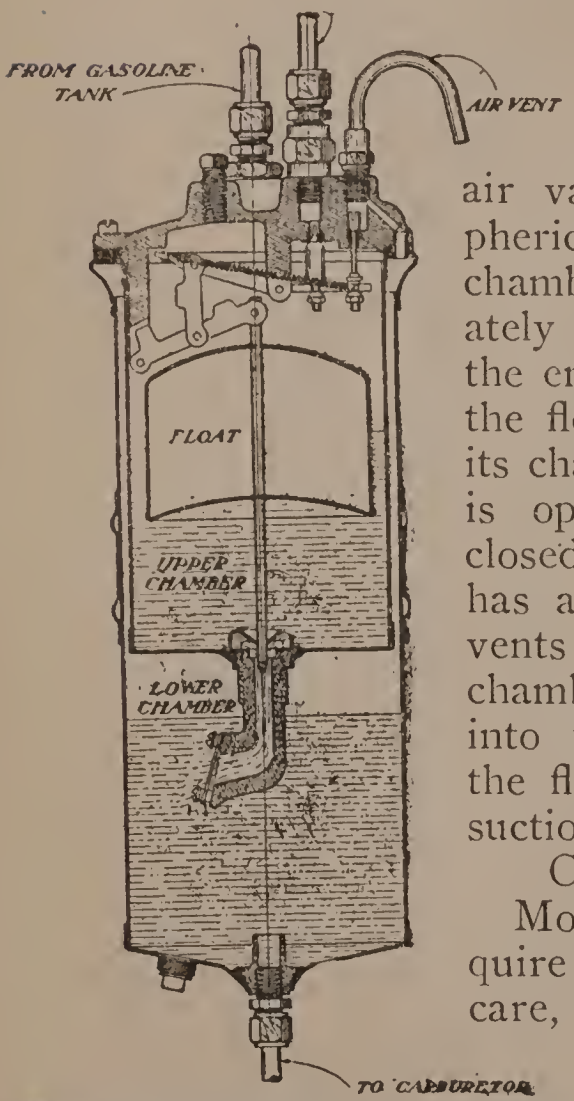

Fig. 21.—Sectional view of vacuum tank, showing internal construction.

Care of the Engine.

Motor truck engines require a certain amount of care, such as providing the proper amount of oil and water to efficiently lubricate and cool the engine. Three or four times a year, or as the maker directs, the oil should be drawn from the crankcase and replenished with a fresh supply. When this is being done it is a good idea to fill the reservoir with about 1½ gallons kerosene and then spin

the motor by hand a few minutes, so that the kerosene will remove all dirt which may have accumulated. Also thoroughly clean the strainer at the pump. It will occasionally be necessary to scrape carbon and, in order to retard its accumulation, about a tablespoonful of kerosene should be put into each cylinder every night. This kerosene will not remove it, but will dissolve it to a certain extent, so that it will loosen and pass out through the exhaust.

The valves will occasionally require adjusting and grinding and this should be done promptly, when necessary, in order to keep the engine working at its maximum efficiency. An engine should never be permitted to race, miss, or labor, as this increases the stress on the bearings and major parts, and will soon make overhauling necessary. Remember that a motor truck engine works at full load almost continuously. Should a knock occur due to a worn bearing, repair it, or have it repaired immediately, so that other parts will not suffer.

The spark plugs will require cleaning, while, after long periods of continued service, the breaker points of the circuit breaker will require cleaning and perhaps adjustment. Cleaning can generally be accomplished by squirting a little gasoline on them and wiping dry with a cloth free from lint. As a general rule, ignition troubles are due to the spark plug or wiring.

The carburetor and fuel supply system will require very little attention aside from an occasional cleaning to remove water and dirt which passes through the fine strainer into the float chamber.

CHAPTER III.

Radiators and Cooling System.

Function of system, Radiator construction and mounting. Care of cooling system.

THE cylinder walls must be kept cool for two reasons. One is to permit of proper lubrication, without which the engine could not operate. Lubricating oil has a definite flash point, and when this temperature is reached it will burn and leave a carbon residue. The second reason is to prevent pre-ignition. If the metal be permitted to heat up to a red heat, for instance, the fuel will ignite during the compression stroke, previous to the completion of same, and thus cause the engine to reverse.

Water is universally used for the cooling of motor truck engines, this being circulated through the cooling system, absorbs heat from the cylinder walls and delivers same to a current of air, which is passed over the surfaces of a radiator within which the water in its heated state is circulated. This is known as the indirect type of cooling system.

The operation of this cooling system may be depicted as follows: Water is circulated from the lower tank of the radiator to a pump, mounted on the engine, which forces the water through a distributing manifold to the various cylinders of the engine. This water is usually entered at the bottom of the water jackets and, as it becomes heated it loses its specific gravity, rises, and flows out through the upper manifold to the top of the radiator, when it is distributed to the various

tubes, through which it flows to the lower tank and is again circulated. These radiator tubes are separated by air spaces through which air passes, carrying off the heat units in the water.

There are two methods of circulating water, by pressure, or natural circulation. The thermo-syphon system is generally referred to as the natural circulating system, while the pressure system incorporates a pump to force circulation. In the former system the pump is eliminated and circulation is induced by the heat of the engine. That is, the water, under the influence of heat, sets up a circulation, and it can readily be understood that the heat replaces the pump as the moving force acting upon the water.

In order that the cooling may be effective, independent of the car speed, a fan must be used. To cool an engine, as used in the modern motor truck, under ideal conditions and most efficiently, would require a tremendously large radiator, if the car stood still, or the air was allowed to flow through it naturally. So, to reduce the size to something that can be used, the relative efficiency is increased. This is done inducing a flow of air, which can be brought about in two ways. One is that the radiator does not stand still, but is moved with the vehicle, inducing an air circulation through it. This, however, would not be effective with the vehicle standing still and the engine running, so a second means of circulation is provided for by the fan, which is driven by the engine. If the engine runs slowly and has little heat to dispose of, the fan runs slow. When the engine is working at its maximum speed, the fan, too, is running at a maximum, creating a very rapid circulation of air through the radiator core. This fan is generally placed in front of the engine, immediately back of the radiator,

and in some cases it is enclosed in a shroud to increase the effective radiating area. Fig. 22 illustrates the conventional type of fan.

Types of Radiators.

Many different types of radiators have been worked out since the motor truck was introduced, however, we have today practically a standard, since the principal variation in its construction is in the core. Conventional design consists of cast tanks and supporting brackets, as

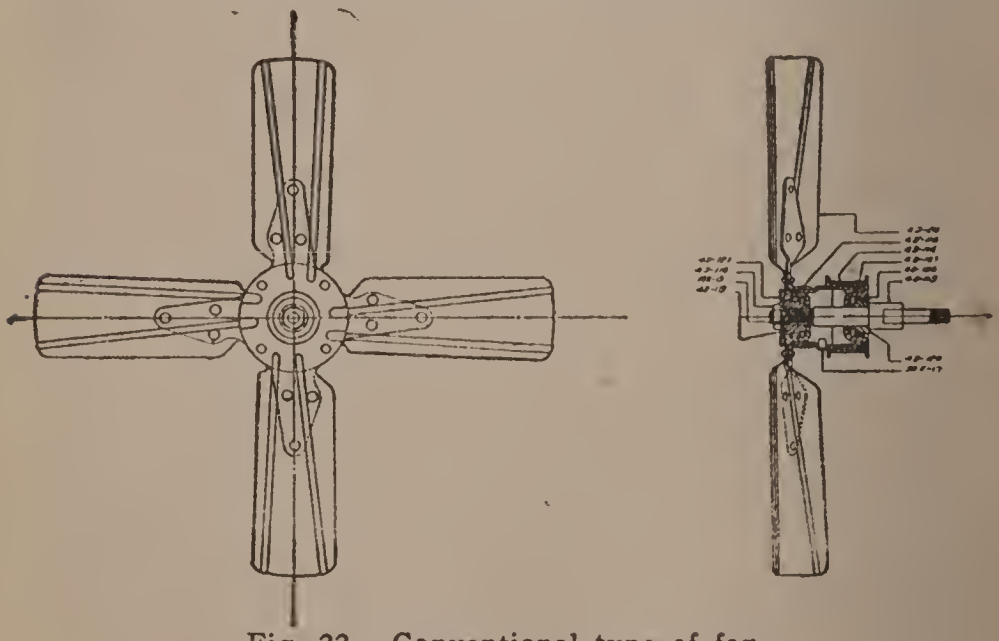

Fig. 22.—Conventional type of fan.

illustrated in Fig. 23, which are bolted to the core, the latter being provided with header plates soldered to the core section. The upper and lower tanks are sometimes provided with fins to assist in cooling, and the design of the tanks is usually such as to provide ample water capacity. By building up a radiator as outlined above, the service problem is simplified, since the radiator can be dismantled for repairs and cleaning when necessary. Repairs can be made at small expense and with little delay. Whereas, damage to a

sheet metal radiator means an expensive and unsatisfactory repair job or a complete new radiator.

Function of Radiator Core.

The heated water entering the tanks is cooled by the air rushing through the air passages in the radiator core, as it slowly descends in small streams through the core to the lower tank. The core consists of a large number of small water passages, the walls of which are exposed to the currents of air passing through the core. The circulation of the water causes it to absorb heat from the cylinder walls, and this heat is delivered to the currents of air which pass through the radiator. As the water in its heated state is circulated in small streams through the core, the air passing over the walls of the core causes the heat to radiate and thus permit the water to be gradually cooled.

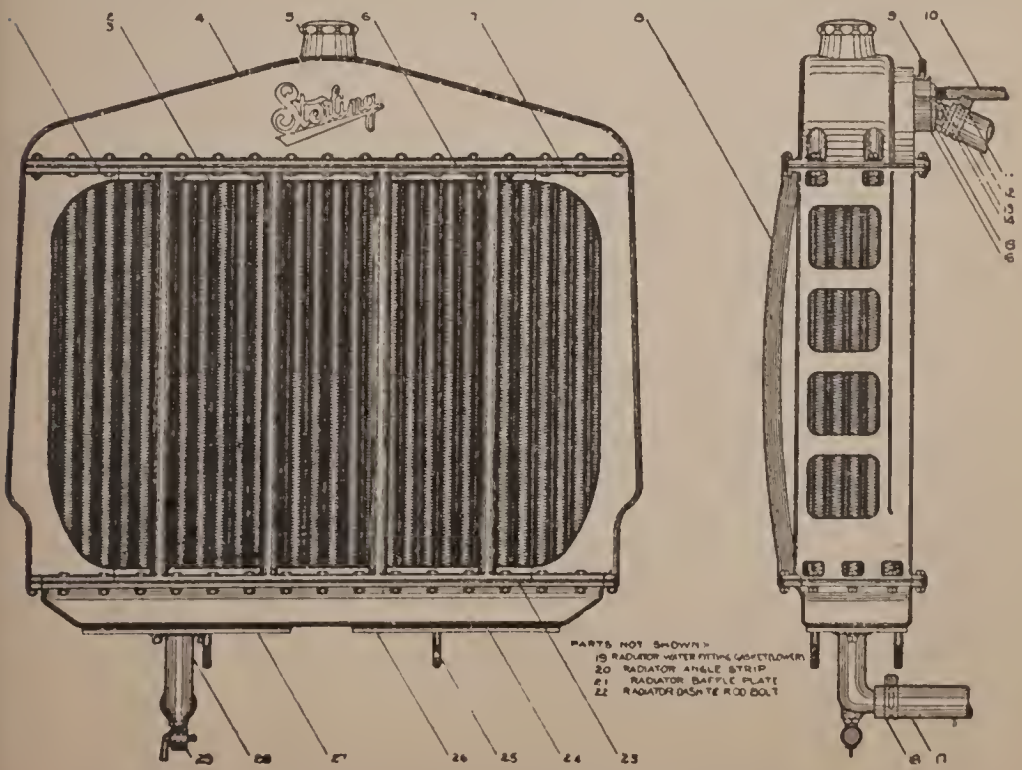
Stanley
PARTS NOT SHOWN
19 RADIATOR WATER FITTING GASKET FLOWER
20 RADIATOR ANGLE STRIP
21 RADIATOR BAFFLE PLATE
22 RADIATOR DASH TIE ROD BOLT

Fig. 23.—Built-up type of Radiator with cast tanks.

Core Construction.

Many different types of construction are in evidence upon modern motor trucks, among which may be found the cellular, flat vertical type and the built-up round and flat tube types.

The cellular type consists of a series of square tubes fastened into a header plate in such a way as to provide space between the tubes for the passage of water.

The flat vertical tube type consists of a series of rectangular-shaped tubes fastened into a header, with fins attached to the tubes for heat radiation and to strengthen the vertical tubes.

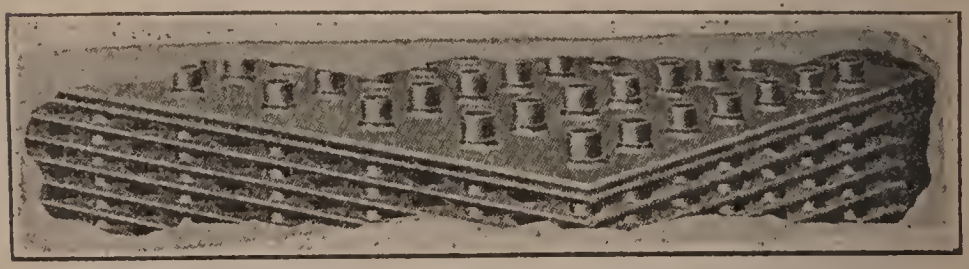

Fig. 24.—Vertical tube type of core with continuous fins.

Various types of fin construction are used, and sometimes these are of the continuous type, the result being a pleasing appearance similar to the cellular type.

Some of the more prominent constructions are illustrated, and a brief description will serve to cover their construction. Fig. 24 illustrates the McCord vertical tube type, which is extensively used. The tubes are of brass or copper with an inside lock seam, and are dipped in solder. They are spaced at one-inch centers from side to side and one-half-inch centers from front to back. The fins are also of copper or brass, spaced five, six or seven to the inch, as the occa-

sion demands. These fins are of the continuous type and so constructed as to provide maximum strength.

The Long radiator core is also a vertical tube type, shown in Fig. 25. This form of core is slightly heavier than the above type and has a relatively large water capacity and is exceptionally strong mechanically. The crimped ribbon from which the spiral flange is made is formed mechanically, and is sweated to the seamless tube along its entire length, insuring intimate metallic contact, and, therefore, low resistance to the flow of heat. With this "spiral" flange tube it is possible to obtain the required degree of rigidity in very large radiators.

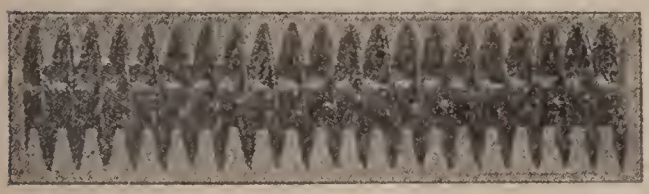

Fig. 25.—Spiral fin and vertical tube.

Various other car constructions are shown in Figs. 26, 27 and 28, all of which have been extensively used. Considerable can be written on this subject; however, the illustrations presented will serve to give the reader an excellent idea of core construction, while Fig. 29 illustrates how these are assembled to the tanks.

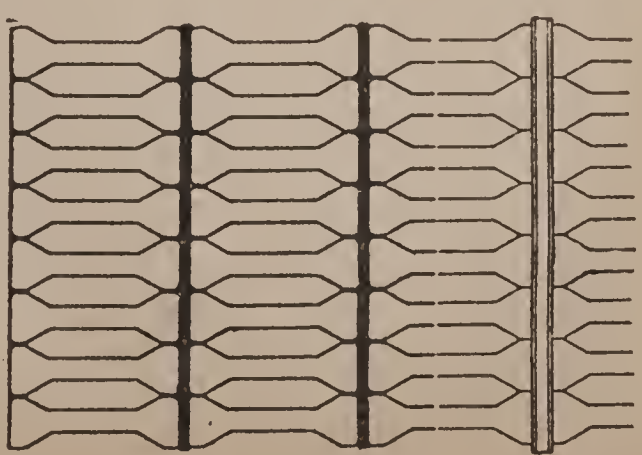

Fig. 26.

Care of Radiator and Cooling System.

The essential parts of the cooling system are: the

radiator, pump, water jackets and pipe connections, and any difficulties experienced in the cooling system can be traced to these parts, providing the vehicle is properly driven and the engine well lubricated. The first essential in the care of the cooling system is to maintain the proper water level in the radiator. The level should be such that it may be readily noted by removing the radiator filler cap. If the water is circulated by the natural or thermo-syphon system, the level must never be permitted to drop lower than the height of the inlet to the jackets. If it does, the water cannot circulate and the engine will rapidly heat up and seize. The supply of water should be replenished daily; that is, what little boils out during the day should be replaced the following morning. Proof of circulation may be had by removing the filler cap, and looking down, you will note streams of water issuing from the back of the radiator near the top. Another method is to turn the engine over a few times so as to circulate the water through the cooling system. If the water level decreases when turning the motor over, keep adding water until it is up to the proper level.

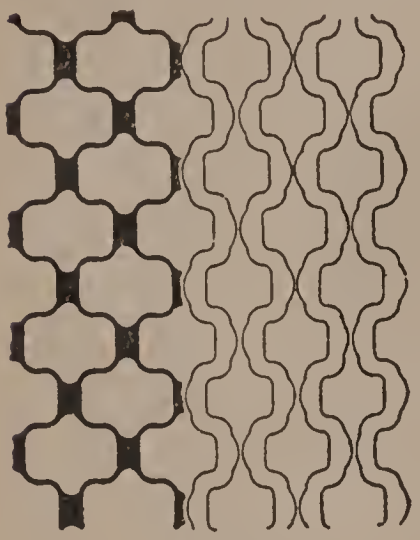

Fig. 27.

Fig. 28.

Most difficulties with cooling systems are due to the radiator or connections leaking. A great many leaks are caused by water freezing during the winter months, when the consequent expansion of ice may break the seams of the tubes. Ordinary leaks can sometimes be mended with the various radiator and boiler compounds available. However, the safest method is to have the leak soldered by some one who does this work frequently. If such service is not available, it is best to consult the manufacturer, who will gladly forward the address of his nearest service station. In handling a radiator, extreme care must be taken, as it is a delicate unit that can easily be damaged.

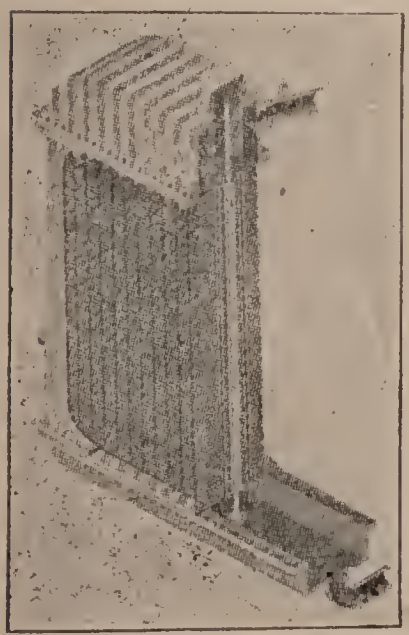

Fig. 29.—Cross section of radiator and core, showing how tanks and core are assembled.

Mounting of Radiators.

Radiators may be mounted in two positions in the chassis frame; either in front of the engine, so that the air currents pass through the core unobstructed, or in back of the engine against the dashboard. The heavy vibrations accompanying high speeds on rough pavements, and the distortion of the frame place heavy strains on the radiator, so that it becomes necessary to provide a flexible mounting, to absorb strains due to shocks and distortion. Springs are usually employed to absorb vibrations, while to protect the radiator against frame distortion it usually is provided with a sort

of three-point support. There is a tendency to make these supports of the universal type, so that the radiator can follow any distortional movement of the frame without the least strain being placed upon it.

CHAPTER IV.

The Transmission and Clutch.

Cone and disc types of clutches. Sliding gear and constant mesh types of transmissions.

THE engine crankshaft rotates at a speed consistent with power requirements, while the road wheels must rotate consistent with road conditions or as the operator wills, so that when the velocity of the road wheel changes, it does not necessarily follow that the crankshaft will change in the same ratio. But in order to vary the rate of speed of the road wheels without changing the speed of the crankshaft of the motor it is necessary to provide some form of transmission which will permit of varying the ratio of speed between the engine and road wheels.

The internal combustion engine cannot develop its full torque or pulling power from a standstill for the reason mentioned above. Further, the motor must be started by a hand-crank, or some starting device, which only produces enough torque to just turn the motor over against compression, so that it becomes necessary to disconnect it from the driving mechanism. For this purpose a clutch is used, which allows a certain amount of slippage until the motor speed has been reduced, or the vehicle speed gradually accelerated to such a point that the two correspond, thus relieving the driving mechanism of shock and jar.

If the internal engine could be so designed as

to afford an increasing torque with decreasing speed, all would be well, and both clutch and transmission could be eliminated. As it is, taking in account the power of the motor at several speeds, nothing of this sort can be considered. At very low speed the torque becomes of greatest importance; this is especially true under certain conditions of operation.

For instance, in starting a vehicle, or when the engine is loaded above a certain limit, it slows down, and the interval between explosions or working strokes in each cylinder becomes so far apart as to cause the engine to labor and finally stop altogether, unless some means is provided to decrease the load upon it. The clutch permits of momentarily disconnecting the load from the engine, while through the various gear ratios of the transmission the torque of the motor can be multiplied.

This term "torque" may be defined as pulling power or the turning effort of the crankshaft. In considering this subject it must be remembered that when an engine is using its maximum power, it may be divided, either in considerable pulling power with low speed, or high speed with low pulling power. Consequently, when a vehicle is traveling at a high rate of speed and a considerable grade or a stretch of heavy road is encountered, the vehicle will begin to slow down until the speed reaches such a point that the engine will labor and knock. When this point is reached it becomes necessary to momentarily disconnect the engine from the vehicle and to change to a lower gear ratio, which for the same vehicle speed gives a considerably larger number of revolutions of the engine crankshaft, thus reducing the load upon the engine.

Clutch Location.

Clutch location has been standardized, and this unit is now universally mounted in the flywheel of the engine. A single clutch is employed, which is normally held in engagement by springs, being controlled through a foot-pedal which acts as a means of releasing the frictional surfaces, thus disconnecting the power of the motor from the driving units. When it is desired to disconnect the engine in order to stop the car, or to change the gear, the clutch is first disengaged by foot pressure upon the pedal, which compresses the springs, releasing the frictional surfaces; the gear is then disengaged or changed and the clutch let in again.

All motor truck transmissions are of the gear type, providing either three or four speeds forward and a reverse. In some cases the gears are continually in mesh and jaw clutches are used to effect the various speed reductions. In this case the gears are free to rotate on their shafts, while the jaw clutches act as a means of driving the shafts. In the other type the gears are permanently fastened to the shaft, several of them being so arranged as to permit them to be shifted to effect the various ratios.

Construction of Transmission.

Either type consists of two parallel shafts mounted on suitable bearings in a housing called the transmission case, which is usually made of aluminum or cast iron. The first of these shafts is known as the primary or main shaft. This is divided into two parts, the forward or driving end and the rear or driven end, the latter being provided with a bearing at its forward end inside the former. The second of these shafts is known as the secondary or counter shaft. The

driven part of the main shaft is of such cross-section or shape as to cause the gears to always rotate with it, but the gears while being forced to rotate with the shaft are so arranged to permit sliding them axially along the shaft. The countershaft has a number of gears fixed upon it, the number depending upon the number of forward speeds which are provided. These gears are so spaced that by shifting the sliding gears, corresponding gears on the two shafts can be brought into mesh successively without interference from other gears. Shifting of the sliding gears is accomplished by a hand lever located conveniently to the operator and a suitable linkage. The shifter rod in the transmission carries a fork which is attached to the sliding gears in such a manner as to permit them to rotate with their shaft.

Types and Construction of Clutches.

There are several types of clutches, all of which have a certain frictional surface which is held in engagement by one large spring or several small springs. It must be designed so that in starting the vehicle it will be capable of transferring the engine torque to the stationary transmission mechanism without shock. This action requires periods of slipping between the clutch members, resulting in the generation of heat, which must be absorbed by them. As it is necessary for the engine to be running at considerable speed to develop sufficient power to start a heavily loaded vehicle, motor truck clutches are subjected to more abuse than any other part of the chassis in the hands of careless drivers, and careful proportioning is necessary if life and freedom from trouble is desired.

There is a great variety of clutches; how-

ever, the most popular designs are illustrated and described herewith. Constructional details vary considerably, and since these are only of importance to the engineer they will not be discussed in this work. The majority of trucks built

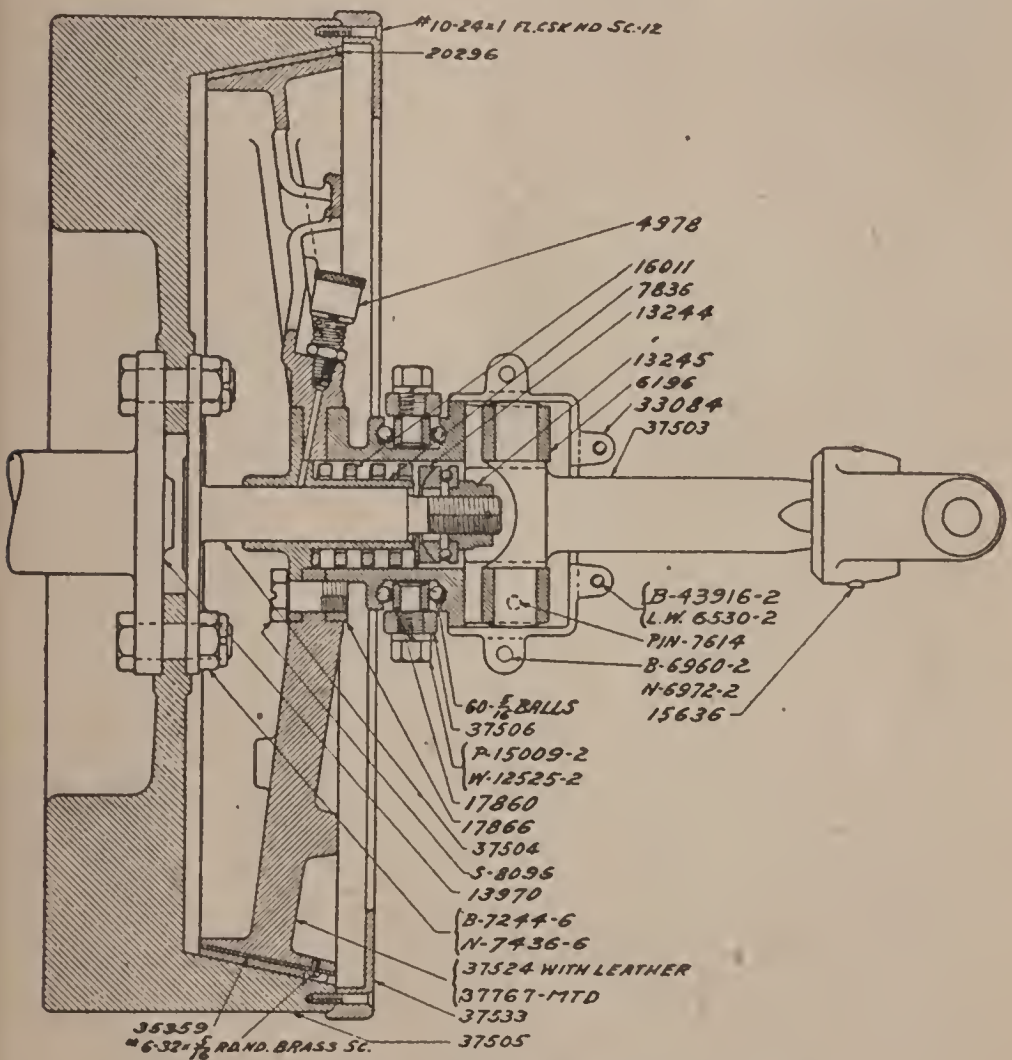

Fig. 30.—Cone clutch used on Pierce trucks.

in this country are assembled from parts made by specialists, and as these cover practically all the important types, they will serve our purpose. Standardization tends to reduce the number of types on account of the necessity of making such units practically interchangeable, or, at least, in so far as their mounting and connections are concerned.

Regardless of type, a clutch must disengage almost simultaneously, and after disengagement it must be entirely free from drag, otherwise gear changing becomes extremely difficult, if not impossible.

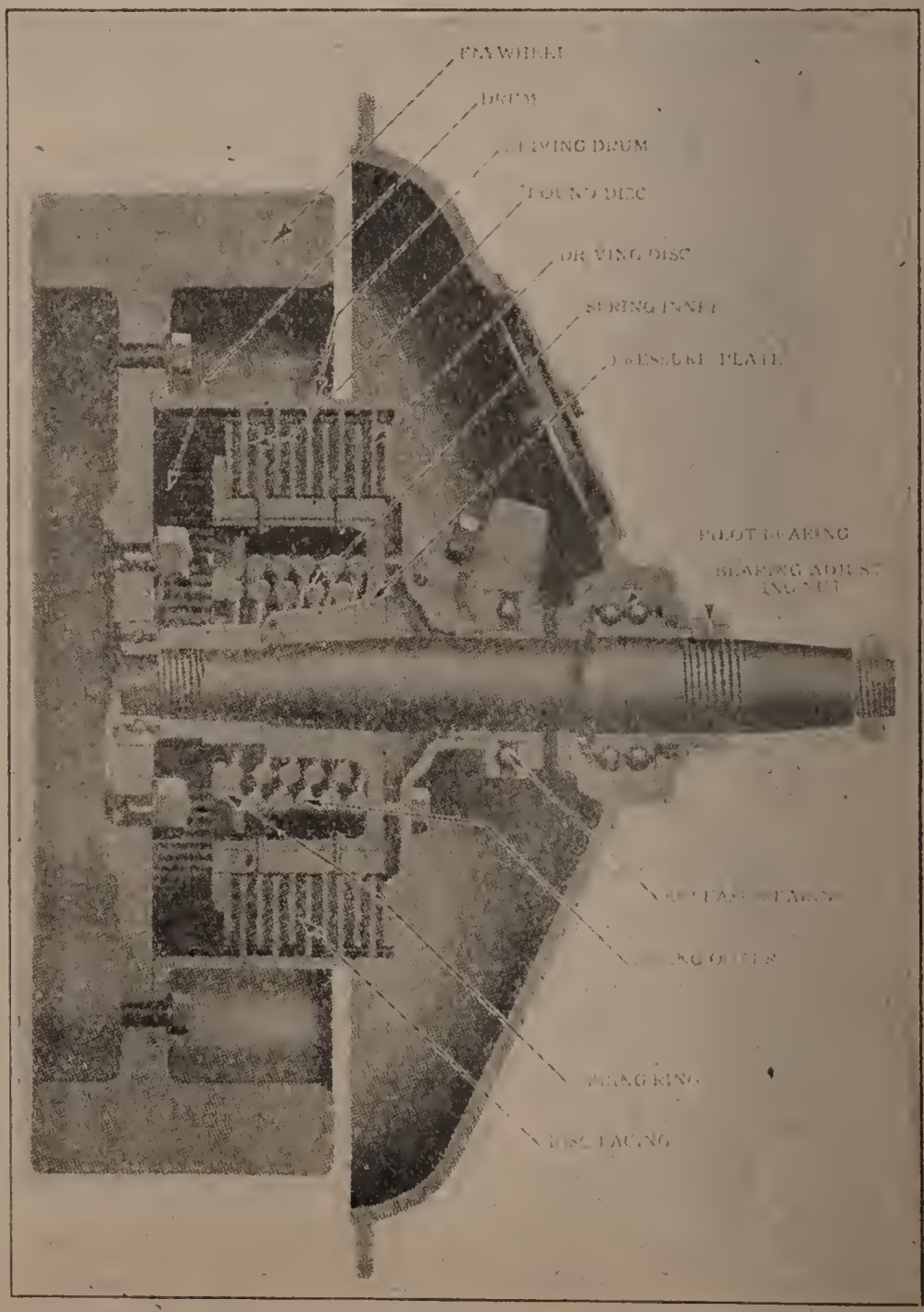

Fig. 31.—Brown & Lipe multiple disc clutch.

Fig. 30 illustrates the cone type of clutch, which is simple in construction, consisting of a wedge member lined with leather. This is often referred to as the male member. The fly-wheel forms the female member, the male member being forced into the female member by means of a spring located on the clutch shaft. The action of these members is similar to a wedge movement. It is the oldest type and also the simplest type in use at present.

Fig. 31 illustrates the Brown & Lipe clutch, which is of the multiple disc type, and may either be operated in oil or dry. It is used on a large number of trucks; in fact, it is universally supplied in connection with their line of transmissions. The housing or driving drum is bolted to the fly-wheel and has teeth cut on its inner periphery into which the plates fit, forming a large number of driving surfaces. The frictional surfaces consist of saw-steel driving discs and raybestos-lined steel-driven discs.

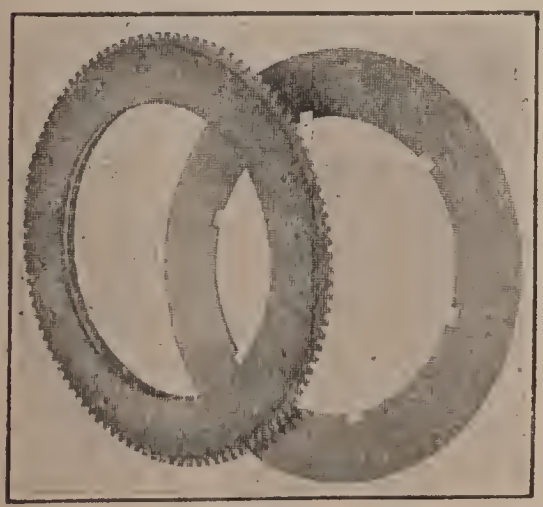

Fig. 32.—Multiple disc clutch plates.

Fig. 32 illustrates in detail the construction of these plates. The various parts are clearly indicated in the illustration, and it will be noted that two heavy coil springs are used to hold the frictional surfaces in engagement. The illustration depicts the housing usually employed when the transmission is mounted amidships.

Another prominent type of clutch is illustrated

in Fig. 33; however, this is of the dry-plate type. This is similar to the multiple disc type, but the discs are of a much larger diameter and but three plates are used. The frictional discs are of some frictional material, such as raybestos, multibestos, etc., while the remaining plates are usually made of cast iron. The face of the fly-wheel forms one surface, while a movable member forms another surface. Between these are located the friction discs and a floating member which is keyed to the driving shaft. Pressure is obtained by a coiled spring acting on a sleeve which actuates the toggle mechanism operating the movable member. This toggle mechanism is supported by a disc which is bolted to the flange. The flange has two slots through which the bolts pass, and this, together with taper surfaces of the movable member, forms of means of adjustment for wear of the frictional surfaces.

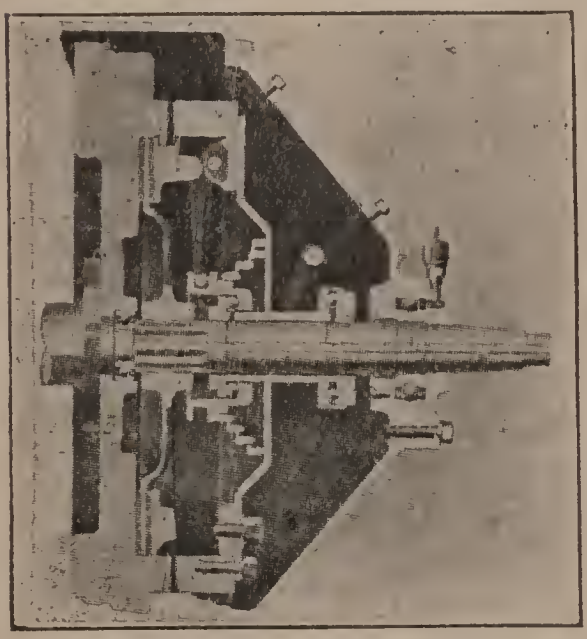

Fig. 33.—Borg & Beck dry plate clutch.

Care of Clutches.

Any of the above types of clutches only require attention occasionally if they are properly operated, such as cleaning the frictional surfaces and adjusting the spring tension. In the cone type with leather face, it is important that the

leather be kept soft and pliable to prevent the clutch from grabbing. This can be done by giving the leather a dressing with neatsfoot oil. When the leather dries out after considerable running, it becomes hard and causes the clutch to grab. If neatsfoot oil cannot be secured, castor oil forms a good substitute. Practically all such clutches are provided with adjustments to prevent slipping, by a series of spring inserts around the clutch spider. When taking up on these adjustments, one should see that they are all taken up evenly. A slipping cone clutch can sometimes be remedied by placing a small amount of Fuller's earth on the friction surface.

The cone clutch with fabric facing, operating in a bath of oil, has similar adjustments. If this type of clutch grabs, the oil bath should be drained out and the bath replaced with a fresh supply of oil.

Most of the multiple disc clutches are adjusted by varying the tension of the clutch springs. Heavy or gummy oil will cause the discs to adhere and the clutch will spin. This type of clutch should be cleaned at regular intervals by flushing the case thoroughly with kerosene and replenishing the oil bath. Slippage of this type of clutch is sometimes due to a weak spring or distortion of the plates. The friction heat will carbonize the oil and pit the plates or coat them with a gummy carbon paste.

The dry plate type is also made adjustable. The adjustment usually consists of set screws which are inserted in a circular slot. In this type of clutch the friction material is a woven fabric, and when these become worn they must be replaced. They can be purchased made up from most any supply house.

Proper clutch operation is also dependent up n

the proper functioning of the disengaging mechanism, and this should at all times be maintained in proper adjustment. Proper lubrication of these members is also essential.

How the Various Speeds Are Obtained.

The transmission may either be located in a unit with the motor or it may be mounted amidship, and the gears shifted through a linkage.

Fig. 34 illustrates a three-speed transmission of the unit type complete with clutch and gear-shifting mechanism. The various speeds are obtained as follows: The forward portion of the main shaft has one gear in constant mesh with the countershaft gear. This countershaft is always in motion when the clutch is engaged and the motor running. Now, when driving on high, there is no reduction in speed through the transmission, since the drive is direct, and it is merely necessary to lock the driving and driven mainshafts. This is accomplished by shifting the gear, *A,* so that the jaw clutches "*I—I*" mesh. In direct drive, gears *A* and *C* run idle. All of the remaining speeds are effected through meshing these gears with their corresponding countershaft gear as follows:

For low speed, sliding gear *C* is meshed with countershaft gear *D,* and the speed reduction is effected through the constant mesh gears to the countershaft, which drives gear *D* thence through gear *C,* which drives the mainshaft through being meshed with *D*. Second speed is obtained in a similar manner, excepting that gears *A* and *B* are meshed instead of *C* and *D*. For reverse, gear *C* is moved to the rear of the case and meshed with a reverse idler gear not shown, which is always in mesh with gear *E*.

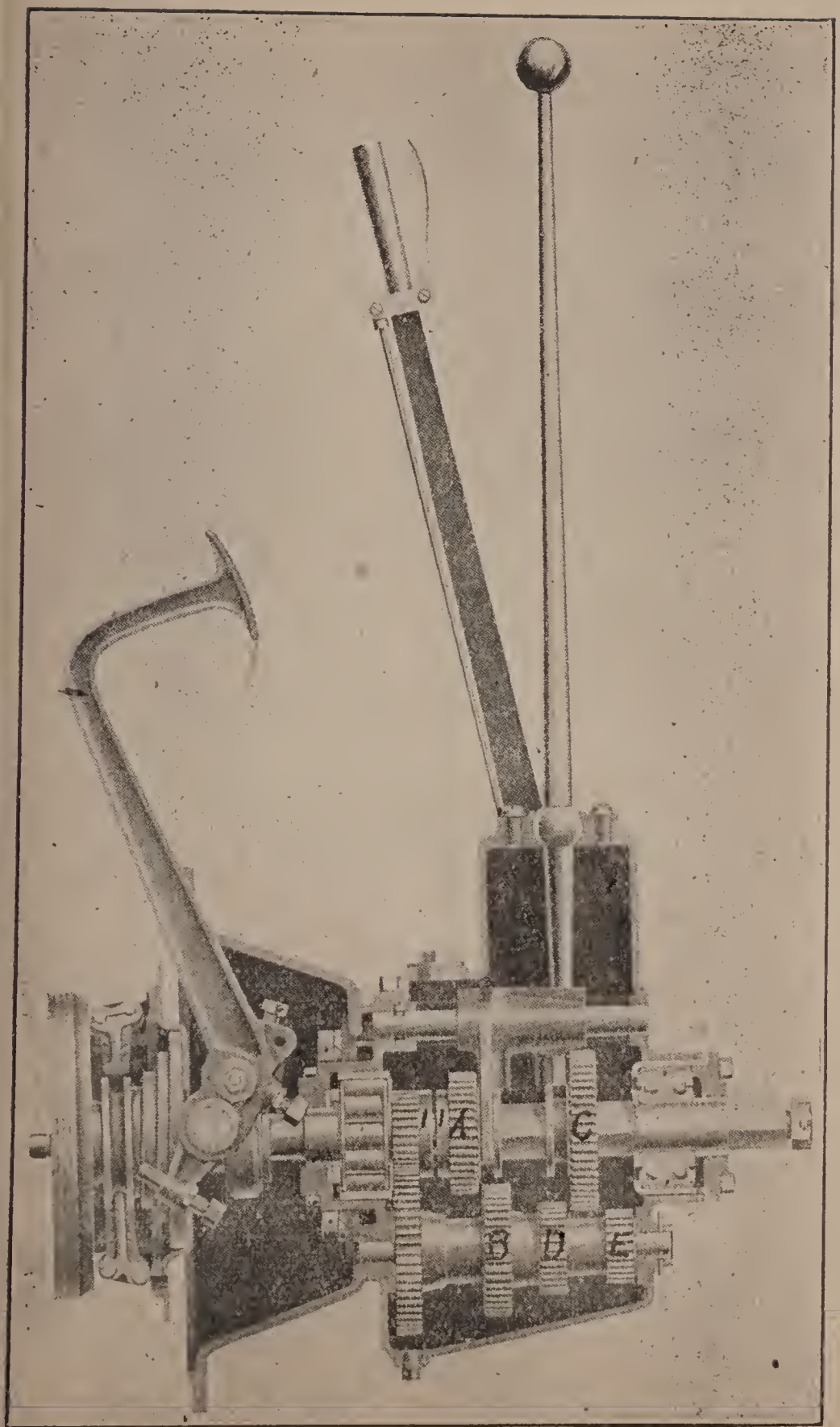

Fig. 34.—A three speed selection type transmission unit with clutch.

Fig. 35 illustrates a four-speed transmission for amidship mounting. The various speeds are effected in a similar manner to that described above. High speed being obtained by locking the main shaft members with jaw clutch "*I—I*"; third speed forward by meshing gears *A* and *B;* second speed forward by meshing gears *C* and *D;* low speed forward by meshing gears *E* and

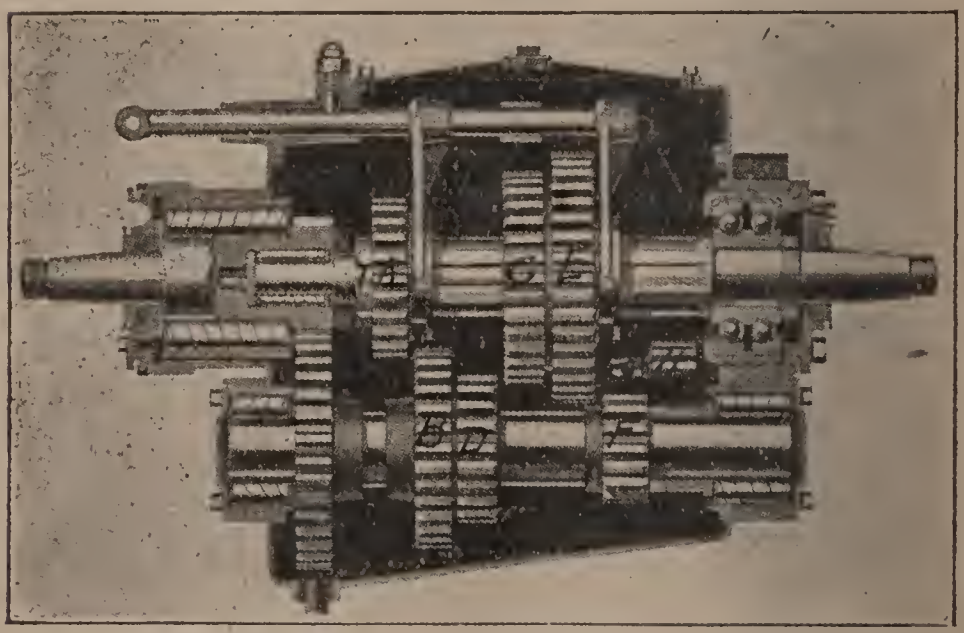

Fig. 35.—A four speed transmission for amidship mounting.

F, and reverse by shifting reverse pinions *G* and *H,* pinion *G* being meshed with gear *E,* while pinion *H* is meshed with gear *F.*

Four-speed transmissions usually provide a very low forward speed reduction and are generally used on trucks of 2½ tons capacity and over.

There is one other type of transmission, known as the constant mesh type, in which all gears remain in mesh continually and the various speeds are effected by jaw clutches. In Fig. 36 five views are shown to depict how these speed

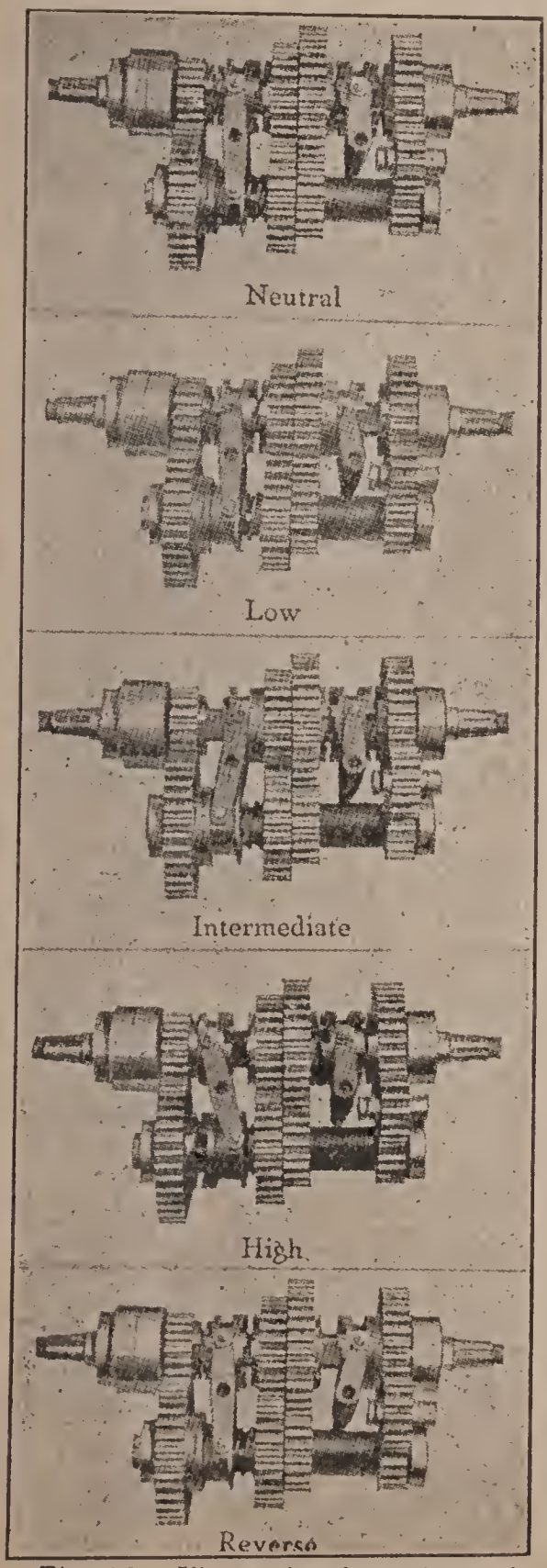

Fig. 36. Illustrating how the various speed changes are obtained in the jaw clutch type of transmission.

changes are accomplished. This type is somewhat related to those described above; the gears are fixed to their respective shafts, but the clutches are free to slide on the shaft.

The planetary type of transmission is not used on motor trucks, with one exception, the Ford. In this, spur gears are used, but they do not slide, the speed changes being effected by brake drums which hold one set stationary. High speed is obtained through a clutch, the entire unit revolving.

Care of Transmission.

Little need be said of a transmission, as it requires very little attention aside from the fact that

it should be lubricated regularly and the hold-down bolts should be kept tight. The lubricant should be neutral and of a good quality; that is, a lubricant that is neither initially acid, or may become acid when subjected to heat. For this reason it is necessary to avoid lubricants containing organic greases, for this has a very destructive action upon the bearings. Difficulties in shifting gears, regardless of whether the trouble lies in the clutch or transmission, should be remedied immediately, as it will eventually become serious.

CHAPTER V.

Axles and Final Drive.

Types of axles, brakes, axle classification. Types of drives.

THE axles may be defined as the bars or beams placed crosswise of the running-gear and carrying on their outer ends the wheels on which the vehicle is rolled. Motor trucks are necessarily fitted with two axles—a front and a rear. The front axle is most generally used for guiding the vehicle, although in the four-wheel drive it is also used for propelling the vehicle. The rear is known as a driving or live axle used for propelling the vehicle, through suitable gearing which converts the power of the motor into propulsive effort in driving the wheels.

The front axle, which carries the front of the vehicle, is generally of the solid type, usually a forging of I-beam section and attached directly to the front springs. Unlike the front axle of a wagon or carriage, the front axle on a motor truck does not turn on a fifth wheel for the purpose of steering, but is fixed to the springs. Movable spindles, which carry the wheels, are provided on the axle ends for the purpose of steering. These spindles are tied together by a rod, so that they move both wheels in the same direction when the car is being turned. The front wheels support the weight of the front end of the vehicle and serve for steering purposes, but in most cases do not assist in propelling the vehicle.

Front Axle Construction.

In American practice there are two general types of steering knuckles, known as the Elliott and reversed Elliott types. The construction of the knuckle and the general type and layout of the bearings are the principal features of design, since the I-beam load-carrying member is universally used. In the Elliott type the ends of the axle proper are forked and the steering knuckle is T-shaped, while in the reversed Elliott type the knuckle is forked and the axle end forms a T. The type of bearing will naturally vary the details of construction. Anti-friction bearings of the ball or roller type are usually employed.

Fig. 37 illustrates the Timken front axle, which is used on a number of commercial vehicles, and

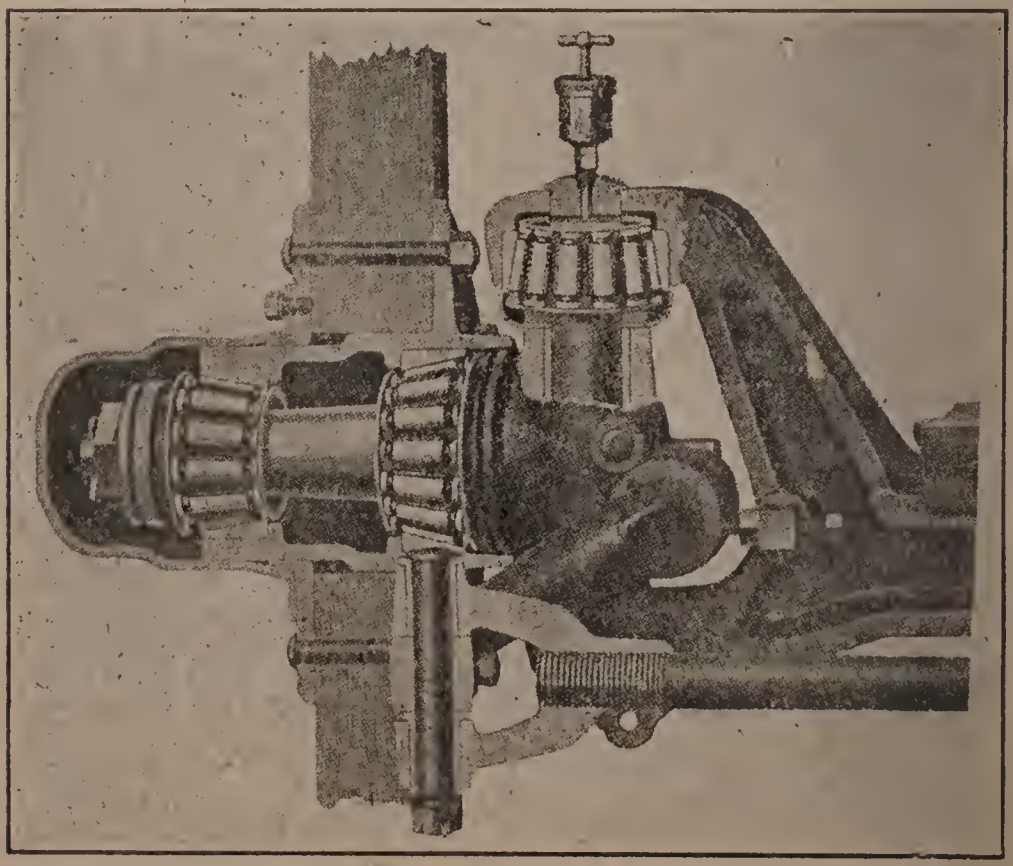

Fig. 37.—Conventional type of front axle with Elliott type knuckles and roller bearings.

Timken roller bearings are used throughout. It has a drop forced load-carrying member and is provided with the Elliott type of knuckle. The knuckle pin—or king pin, as it is sometimes called—is provided with hardened steel bushings and a Timken roller bearing, the latter carrying the load of the vehicle.

Fig. 38 illustrates the front axle used by a prominent maker, which incorporates the reversed Elliott type of knuckle with an I-beam load-carrying member. The bearings of the knuckle pins are of the plain type, provided with shoulders, and so arranged that the thrust is taken by the shoulders of these bushings and a hardened and ground steel washer.

The front axle, with its knuckles and steering connections, is largely depended upon for the safe control of the vehicle, and while it is always of sturdy construction, the bearings and working parts must always be properly lubricated and protected from dirt and grit. Adjustments are usually provided to compensate for wear, and these must be taken up as soon as it develops, for the constant hammering quickly developes it, the wear then becoming very rapid. In order to minimize tire wear, it is necessary to provide a slight amount of toe-in for the wheels, the average being ¼″ to ⅜″.

The Final Drive.

The final drive is the mechanism which transmits the driving effort or power of the motor to the driving wheels. A pair of chains from the final drive of a chain-drive vehicle and shaft-carrying bevel or worm gears forms the final drive of a shaft-driven vehicle.

In the chain drive the power is transmitted to unit carrying the driving sprockets. This unit is

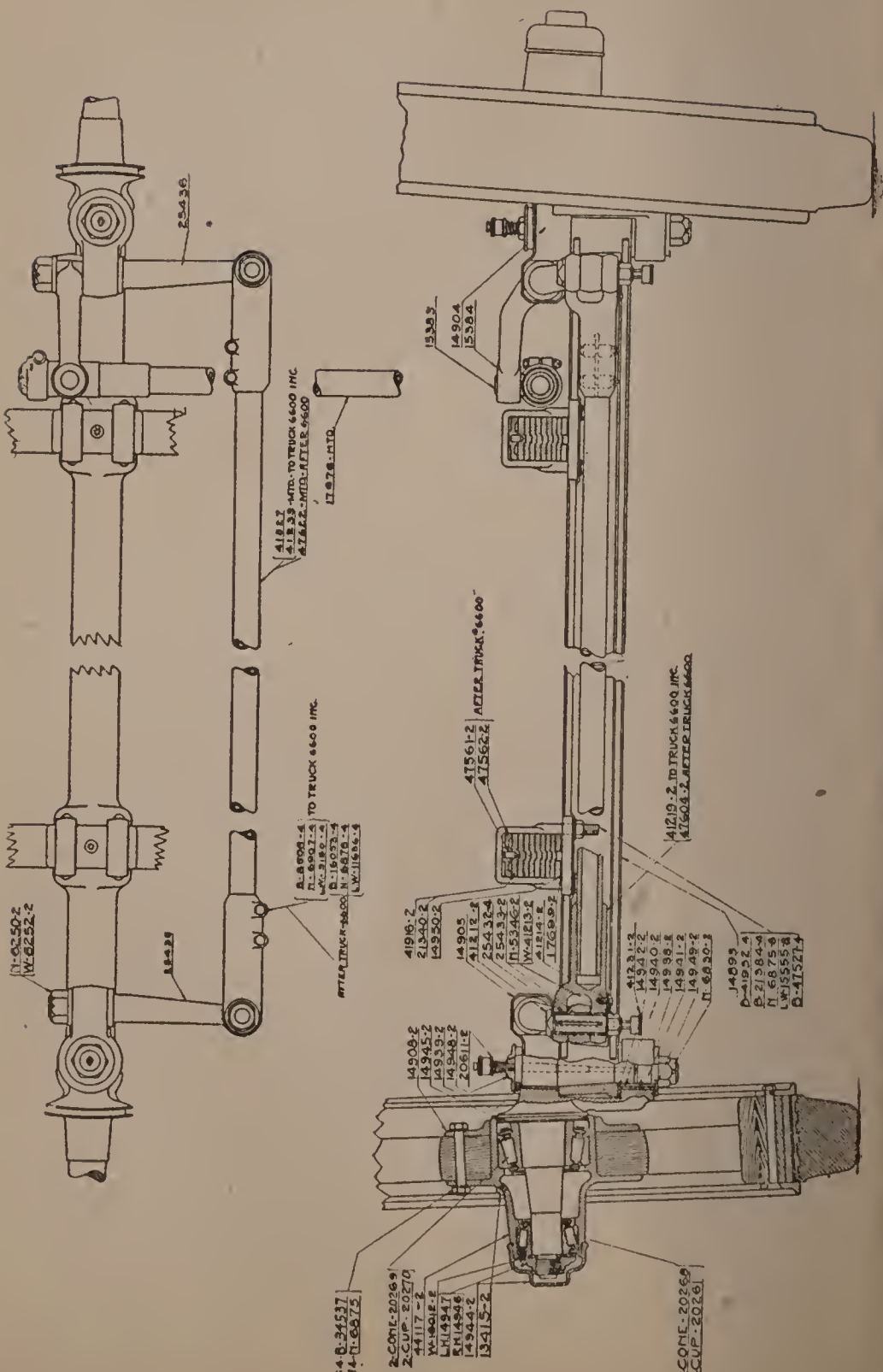

Fig. 38.—Pierce axle with reversed Elliott type knuckles.

generally termed a jackshaft, and is similar to the rear axle of a passenger car, excepting, of course, that it does not carry the weight of the vehicle. For this purpose a dead rear axle is used, which has spindles upon which the wheels and their bearings are mounted. Chain drives, with few exceptions, are only used on vehicles of five-ton capacity and over, the principal reason being, perhaps, the fact that on vehicles of such capacity the unsprung weight is of considerable importance. The principle objection is the attention required to obtain maximum efficiency. It is generally exposed and dirt soon finds its way into the numerous bearings, causing rapid wear.

Shaft-Driven Axles.

Shaft-driven axles vary principally in the type of gearing used and in the method of mounting the wheels. They incorporate a differential gear, the function of which will be explained below; a pair of driving gears and shafts, and a load-carrying member, which in some types is also used as a housing to enclose the driving elements. In this type the axle shafts drive the wheels either through gears or by having the wheels mounted directly on the shafts. There are a variety of types, and in order to depict the construction and features of each, illustrations and descriptions are given below.

The Internal Gear Type.

This type in reality is a double reduction type, similar to the chain drive, in which two sets of gears are used instead of one set of gears and a set of sprockets. It is also similar to the chain drive, in that a jackshaft and dead rear axle are used. However, the two units are bolted together

and the sprockets and chains are replaced with internal gears in the brake drums and spur pinions on the drive shafts. The driving unit is equivalent to the ordinary bevel drive passenger car axle, and may be placed front or rear, top or bottom of the load-carrying member. The load-carrying member may be made a casting, a bar of either round or rectangular section, or the more elaborate I-beam section.

The Clark axle (Fig. 39) is arranged with entirely separate load-carrying and driving mem-

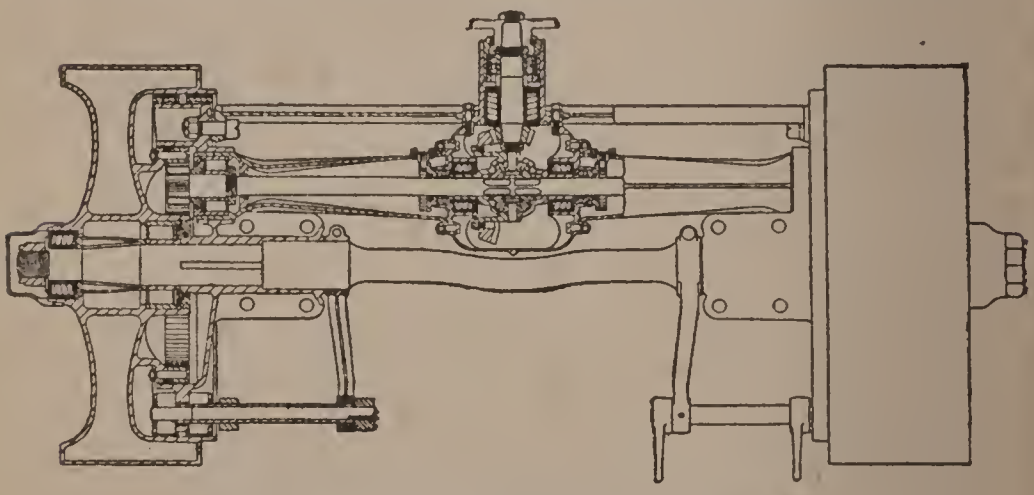

Fig. 39.—Clark internal gear drive axle.

bers. The load-carrying member is a steel forging, offset in the center to clear the jackshaft housing and to hold the proportions of the internal gear within reasonable limits. A feature of this axle is that all parts are identical, there being no rights and lefts. The driving unit or jackshaft is located in front of the load-carrying member and consists of a center housing divided vertically along the center of the pinion shaft. The bevel pinion is mounted on one roller and one double row ball bearing. The differential is mounted on roller bearings and is provided with ball thrust bearings to locate it in either direction. The inner ends of the drive shafts are

provided with square ends which fit into the differential, and the outer ends carry the spur pinions which drive the wheels through the internal gears mounted in the wheel hubs.

The Torbenson axle (Fig. 40) is also of the internal gear type; however, this differs from the above, in that the driving member is located back of the load-carrying member. The load-carrying member is of I-beam section and the wheel spindles are separate and pressed into the load-carrying member. The load-carrying member is pierced at the center and machined to locate the jackshaft housing which is bolted to it. Roller bearings are

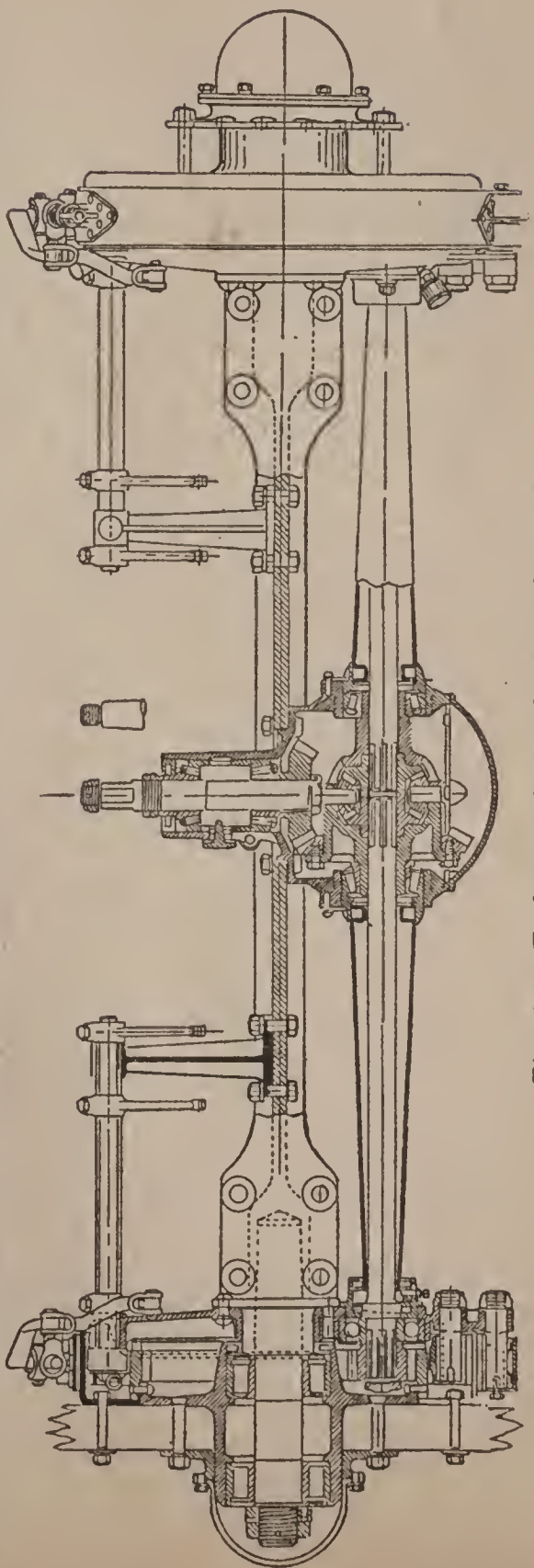

Fig. 40.—Torbenson internal gear drive axle.

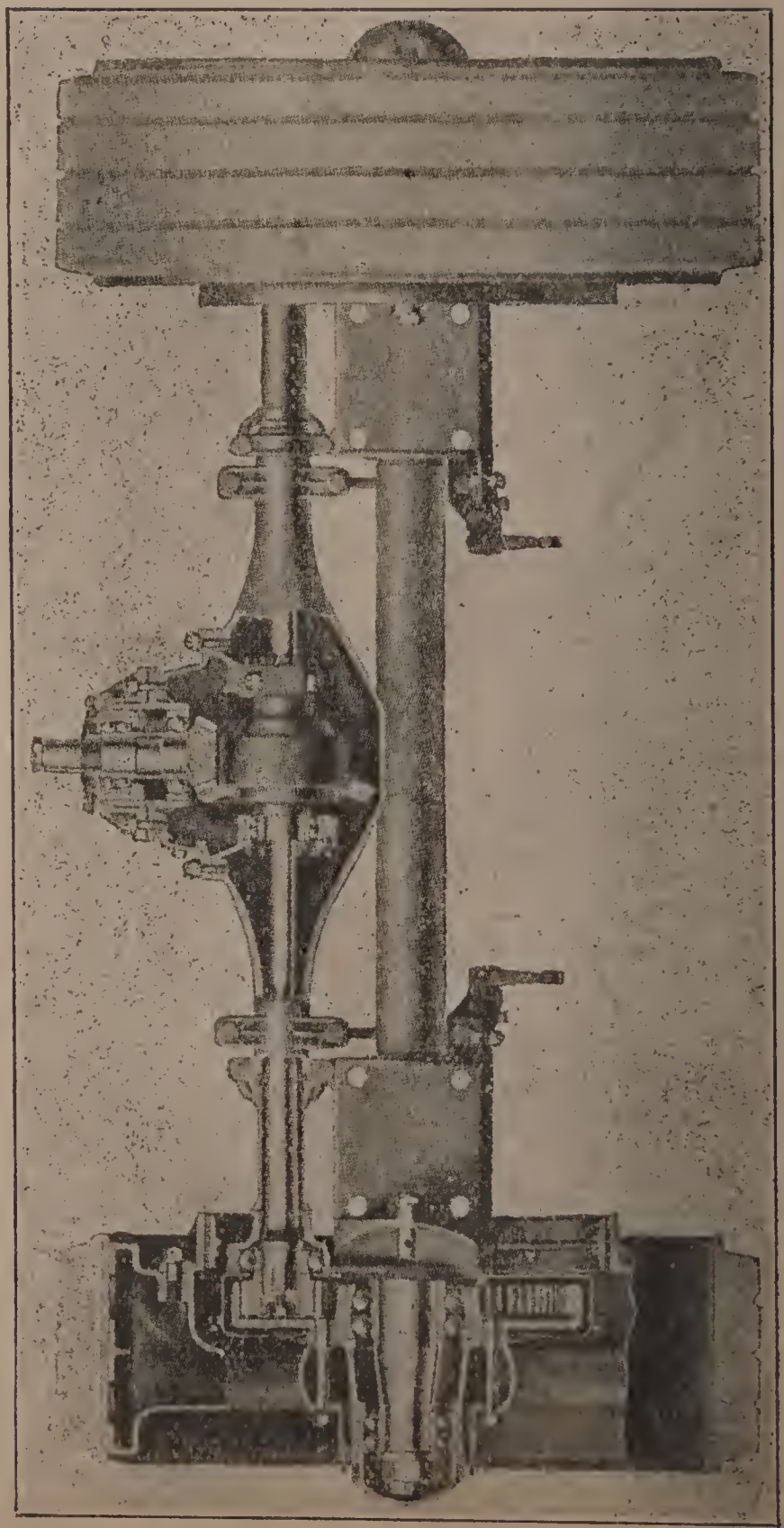

Fig. 41.—Russell internal gear drive axle.

used throughout, with the exception of the spur pinion, which is mounted on ball bearings.

Another type of internal gear axle, known as the Russell, is illustrated in Fig. 41, which has a forged load carrying member of round section. Its general construction is similar to those menioned above. In this type of axle the power applied to the wheel nearer the rim where the leverage is greater, the claim being made that this gives greater efficiency at all speeds. By a comparison of weights of the various types of axles it is evident that this type can be made lighter, thus reducing the unsprung weight on the tires.

The Worm Drive Axle.

The worm drive, in a great many respects, is similar to the passenger car axle, in that all driving gears are located within the differential housing and the wheels are driven direct by shafts instead of through gears. It is perhaps the most simple in construction, since it has the least number of parts, is silent in operation and can easily be arranged for straight line drive. A wide range of gear ratios can be provided without changing the center distance between the worm and wheel, while it also affords ample protection to all parts which are subject to wear. Wheel mountings such as are used on passenger cars are also adaptable to the worm drive axle. Fig. 42 illustrates the power transmitting elements of this axle, and it will be noted that the total speed reduction of the driving element is obtained by means of an intermeshing worm and gear wheel, the latter having teeth so formed that they are acted on and the wheel is made to revolve by the worm or shaft on which a spiral is turned. Details of construction vary considerably with

various makes, and in order to describe these, various illustrations are presented herewith.

Fig. 43 illustrates the Timken axle, which incorporates a pressed steel housing reinforced by steel tubes. The differential, worm and gear wheel and their bearings are all assembled in a unit with the cover. Timken roller bearings are used throughout, and the construction is such that the driving unit may be removed without removing the axle from the vehicle.

Fig. 44 illustrates the worm drive rear axle of the Pierce five-ton truck, which differs somewhat from the above, in that the housing is a heavy steel casting rein-

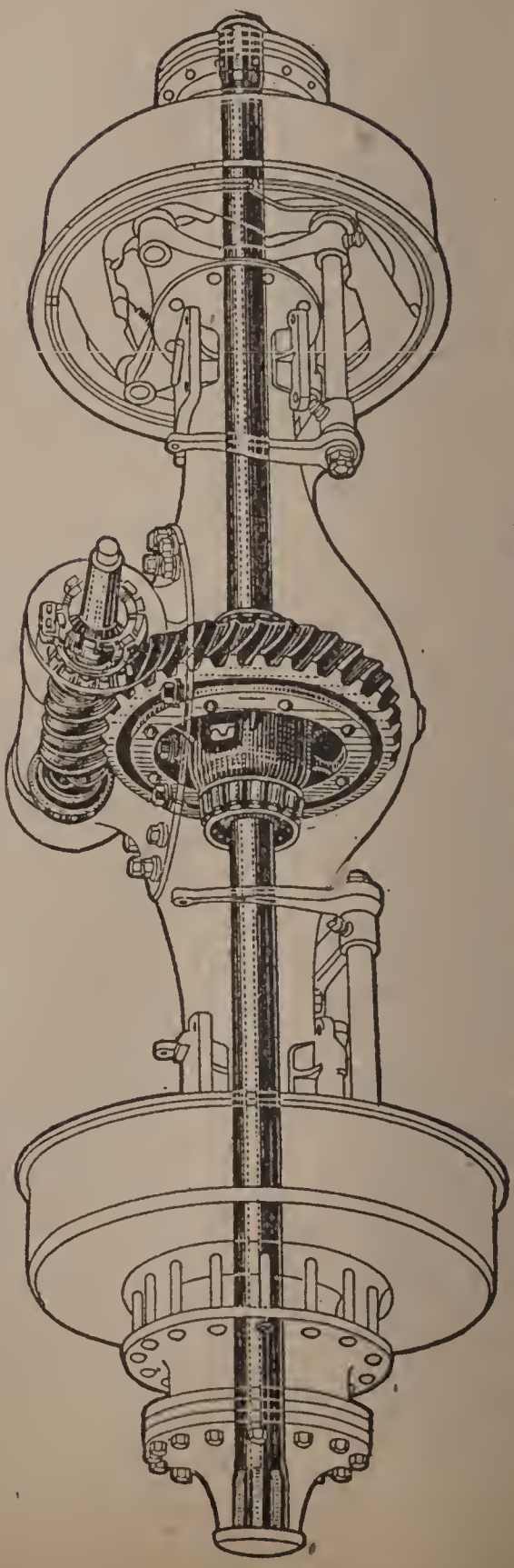

Fig. 42.—Driving elements of a worm drive axle.

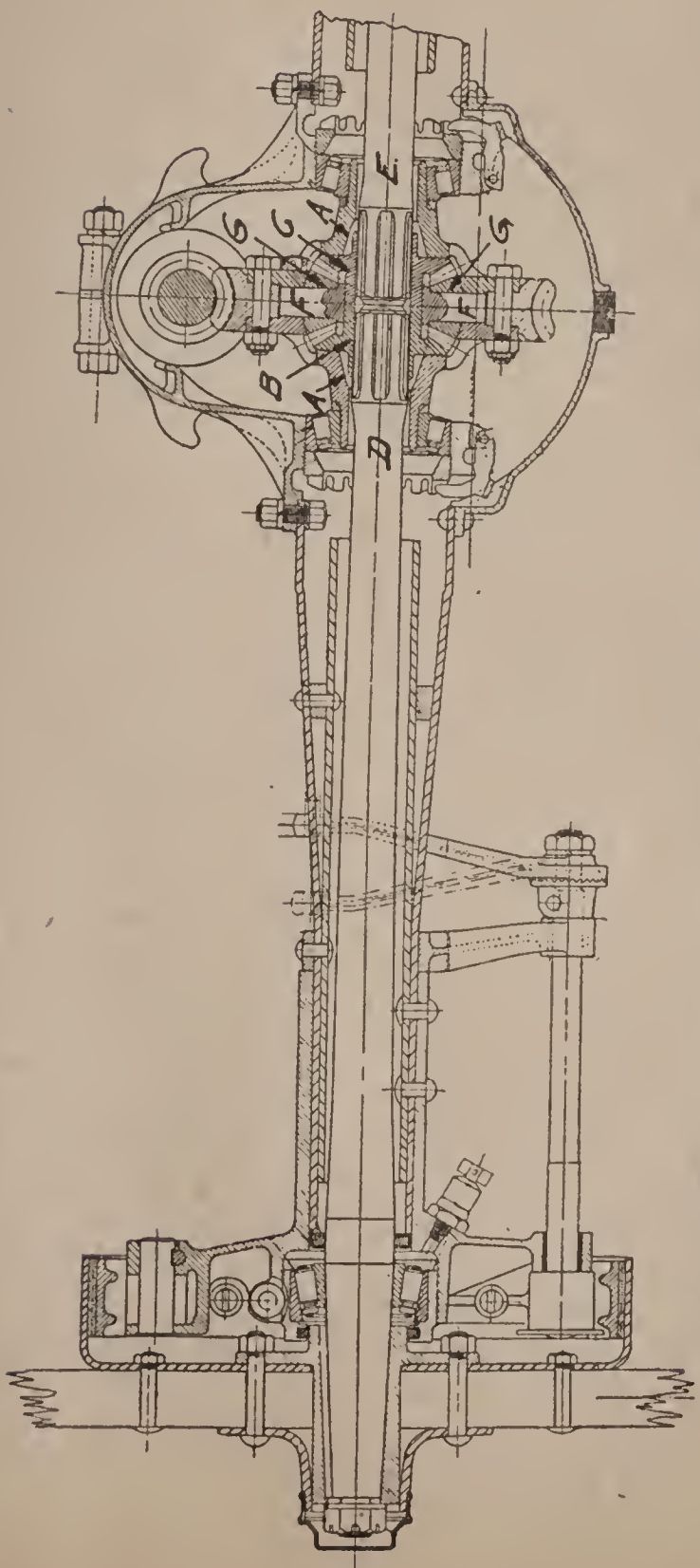

Fig. 43.—Timken worm drive axle, semi-floating type with bevel gear differential.

forced by steel tubes and a truss-rod. The mounting of the wheel bearings is also somewhat different, being of the full floating type instead of semi-floating, while the differential, which is in a unit with the driving elements, is mounted on ball bearings and also provided with ball thrust bearings.

The Differential.

In ordinary language, a differential is an assembly of gears that enables the rear wheels to move at different speeds. Everybody knows that when a motor truck turns a corner the inside wheel, that is, the wheel nearest the curb, revolves slower than the outside wheel.

A simile to this condition is that of a line of soldiers marching. They are all going forward at the same speed; a command is given for a turn to the right; the man at the extreme right of the line immediately begins to mark time; that is, he moves his feet in the same time as all the rest of his fellow-marchers, but his steps are very, very short; in other words, he pivots, simply changes his position before the command, to a certain position at a right angle.

But the man at the extreme left lengthens his stride and increases his speed considerably, in order to keep the line straight, each man from left to right going just a bit slower than his immediate companion on the left. This is really the action of the rear wheels when the vehicle moves away from a straight line. If, as in the case of a horse-drawn wagon, or of the front wheels, each rear wheel was separate and detached from the other or from any common union, there would be no need of a compensating device. However, in the motor truck an entirely different problem is encountered. The two rear wheels, which are the driving members, turn at

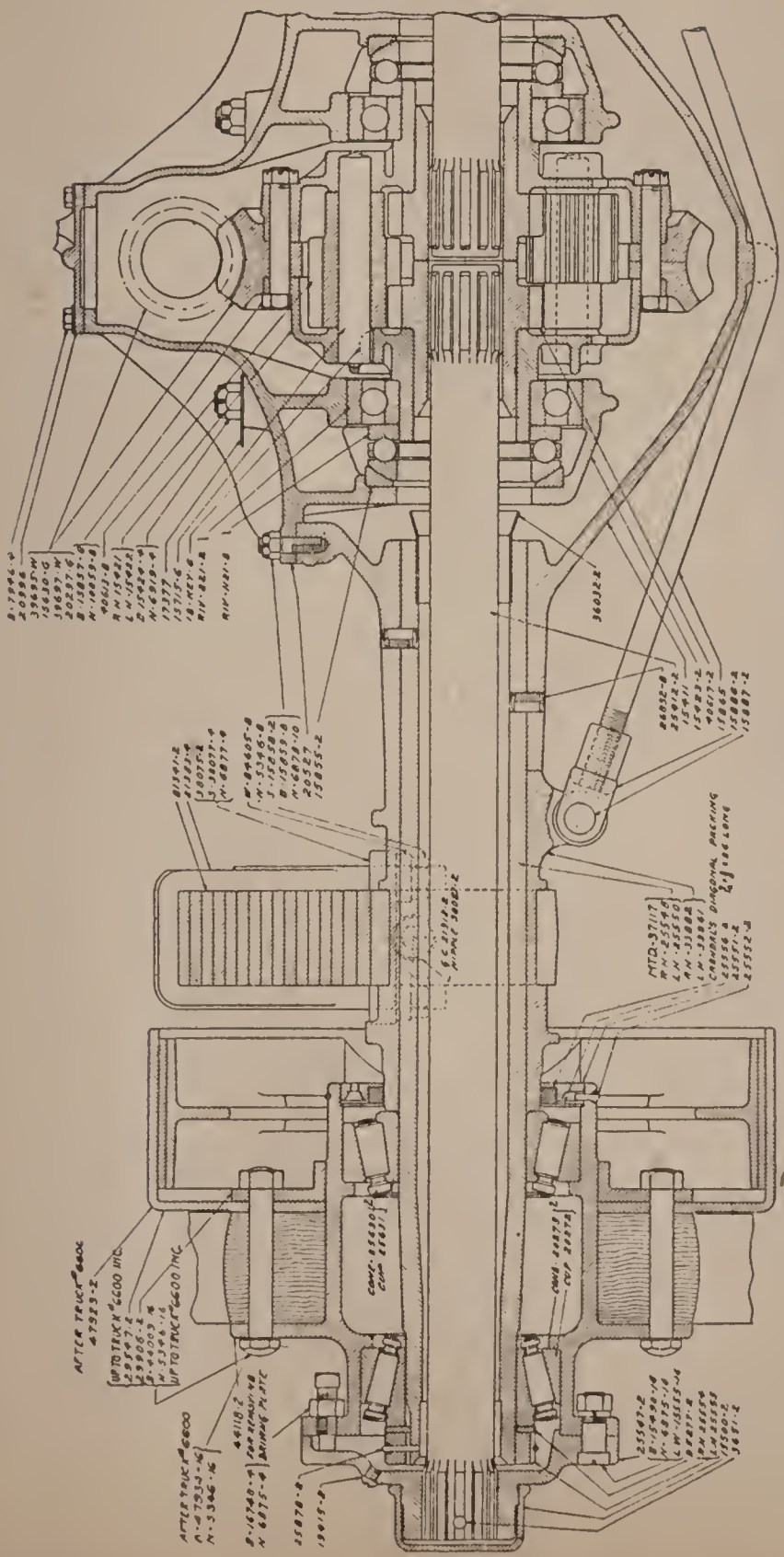

Fig. 44.—Pierce worm drive axle, full floating type with spur gear differential.

the same speed when the vehicle is traveling in a straight line and revolve in proportion to the engine speed. Provision must therefore be made for variance from this condition when the speed of the two wheels becomes different. It is this function of permitting one wheel to go slow and the other to go fast that is performed by what is known as the "differential gear."

The differential consists of a set of spur, bevel or spiral gears located at the center of the rear axle. Its purpose is to divide power transmitted from the engine equally between the two wheels, and to do this in such manner that one wheel may revolve faster than the other when necessary.

There are practically three types of differentials in use, which differ principally in the type of gear used, the spiral type being the latest improvement.

The bevel gear type of differential is illustrated in Fig. 43, and consists of the following parts: A housing, *A;* two bevel gears, *B* and *C,* secured to the driveshafts, *D* and *E,* respectively; a four-armed spider, *F,* on the radial arms of which are carried bevel pinions, *G, G_1, G_2* and *G_3,* meshing with both of the bevel gears, *B* and *C.* The housing carries the driving gear, but this does not form any part of the differential.

The action of this gear may be described as follows: The spider is held to the housing, and the turning effort which is applied to the housing by means of the driving gear is equally divided by the bevel pinion between the bevel gears. As long, therefore, as the resistance of the two road wheels is the same, they will turn at the same speed. If, now, the steering wheel is turned so as to move the vehicle from one side to the other, the inner driving wheel is automatically held back with a force equal to the

road adherence. The bevel gear on that side will then turn slower and its mate on the other side will turn correspondingly faster, while the bevel pinions between these gears will turn on the arms of the spider at a speed corresponding to the difference in speed between the two bevel gears.

The construction of the spur gear type, which is illustrated in Fig. 44, is similar, but the gears are of the spur type. While the hubs of the spur gears come close together, the inner edges of the gears themselves are at some distance apart. These spur gears mesh with spur pinions, which have a width of face almost twice that of the gears. A portion of the face of the pinions mesh together while the remainder meshes with the gears. The action of this type of differential is identical with that explained above. When the vehicle is moving in a straight path the differential gears are inactive and the unit revolves as a whole. But when the vehicle is turning a corner, the spur pinion differentiates the speed between the two wheels as in the bevel type.

Either type of differential is a unit, since it is built into a housing which supports the spider or bearings for the pinions. This unit is always mounted upon some form of anti-friction bearings within the axle housing; if the particular type of bearing employed will not carry thrust loads, a ball thrust bearing must also be used.

Axle Classification.

The weight of the vehicle is supported on the rotating parts in some designs, while in others it is supported on non-rotating parts. This classification is due to the arrangement of the wheel bearings, as in some types these are so mounted that only tortional strains are placed upon the

axle driveshafts, while in others the bearings are mounted directly upon the shaft and it is subject to bending strains in addition to the tortional strains. The former is known as the full-floating type, and the latter is termed a semi-floating type.

Fig. 43 illustrates the semi-floating construction, and it will be noted that the whole bearing is mounted directly upon the driveshaft, the axle tube being riveted into the brake spider. In the

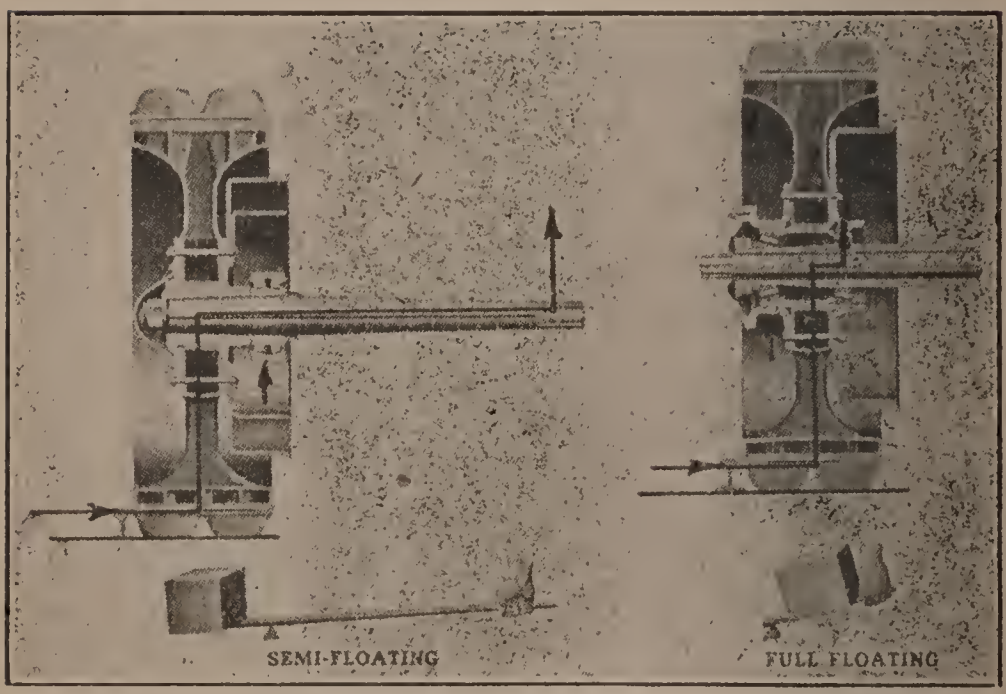

Fig. 45.—A photographic comparison of the semi and full floating types.

full-floating construction (Fig. 44) the axle tube extends through the wheel hub, surrounds the driveshaft and supports the wheel by means of two bearings. Various claims are made for the two constructions, some of which are worthy of attention. In the full-floating type, the axle shafts can be withdrawn without removing the wheel or jacking up the axle, and if for any reason an accident or other cause should result in a broken driving shaft, the axle will not drop

to the ground and the vehicle can be towed in for repairs. Strains due to skidding and thrust loads, as in turning a corner, are more severe on this type than the semi-floating type.

In the semi-floating type these strains are reduced considerably, as will be noted by reference to Fig. 45, which shows a comparison of the two types. This type can also be made lighter, because of the greater distance between bearings. It is also much simpler to repair, and for this reason it is generally claimed that its maintenance cost is lower.

Rear Wheel Brakes.

Brakes may be defined as a mechanical device for arresting or retarding the motion of a vehicle by means of friction, and upon the efficiency of the brakes the safety of the vehicle is dependent. These brakes are usually located in the rear wheels, although in some few cases one brake is mounted upon the propeller shaft. This latter type is described in the chapter on Terminal Joints and Drive Shafts. In horse-drawn vehicles the brakes are applied directly to the steel tires; however, since rubber is quite expensive, this method of brake application is not commercially possible; but it is effectively accomplished by secur-

Fig. 46.—Timken duplex internal expanding brakes.

ing to the wheels a metal drum, on which the friction members act.

Brakes vary greatly in details of construction; however, there are practically two types, the internal expanding and the external contracting types. In some cases one set of each is used, while in others two sets of the internal expanding type are used.

The external is usually of the band type, incorporating a steel band to which a frictional material is riveted. The expanding type usually consists of cast shoes having a friction material

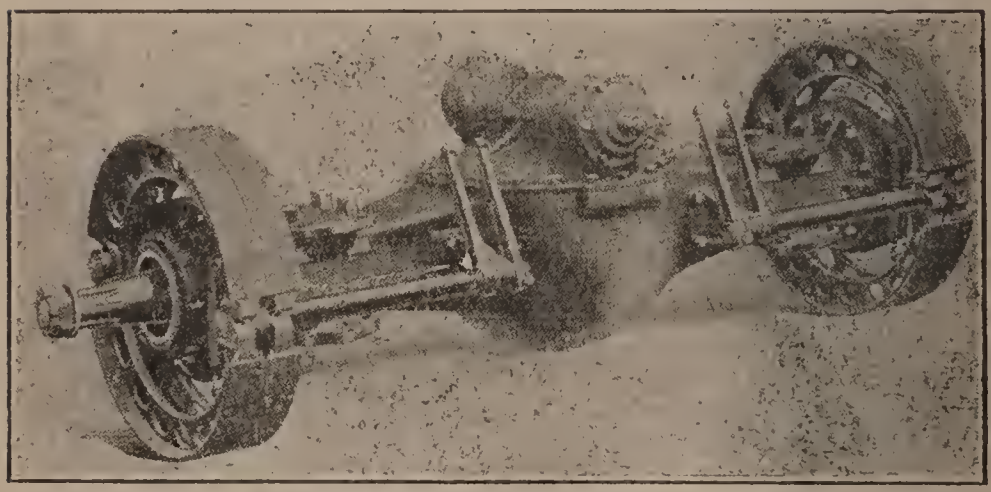

Fig. 47.—Stan-Par axle with internal brakes side by side.

riveted to them. Fig. 46 illustrates the Timken brakes, which are termed a duplex brake, and consist of four friction fabric-lined shoes, so located that the pair of brakes takes up no more room than the ordinary single-shoe type. These four shoes are equally spaced on the inner circumference of the brake drum, on each pair located diametrically opposite are expanded by cams and supported by the brake spider, which is rigidly secured to the axle housing.

Fig. 47 illustrates the internal expanding brakes of the Stan-Par axle. In this case they are

located side by side, each pair operating on a single brake drum of considerable width. This illustration clearly depicts the type of cam usually employed to expand this type of brake.

Fig. 48 illustrates the external type, and also shows how this can be combined with an expanding type to operate on a single drum. The contraction of the band is usually accomplished by means of a toggle mechanism and lever located near the opening of the band. It permits providing a simple adjustment, in the form of a turnbuckle, which is locked in position by lock nuts at either side.

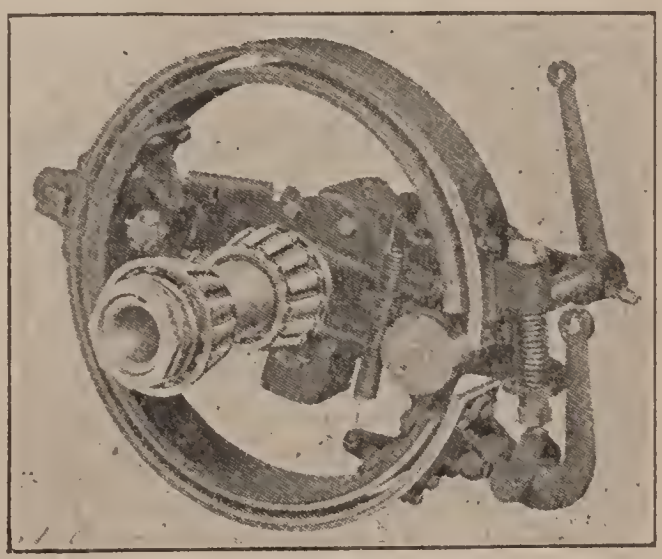

Fig. 48.—Internal and external brakes.

Type of Drive.

A factor of truck construction very widely discussed is the type of drive, which is generally understood as referring to the method of providing for the torsion and propulsion in shaft-driven vehicles. At present there are three general methods, as follows: The Hotchkiss drive, in which the torque and thrust is taken on the springs; torque on springs, thrust on radius rod; and torque on torque arm, thrust on radius rod. The former two methods are by far the most popular, regardless of the type of live axle used.

It is quite evident that the vehicle to move ahead must be pushed forward by some means.

The mechanical energy of the engine is transmitted through the various driving units to the rear wheels, and the turning of these wheels pushes the vehicle ahead through adhesion to the road surface, and the push or propulsion of the wheels must be transmitted to some solid part of the chassis, or the axle would work its way toward the front end of it.

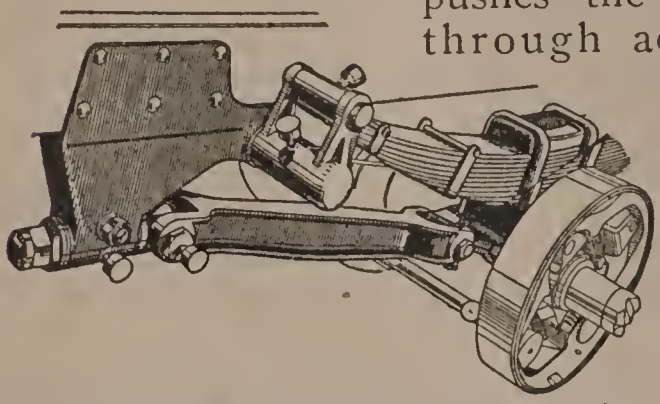

Fig. 49.—G. M. C. radius rod construction.

On the G. M. C. trucks a radius rod is used, as illustrated in Fig. 49, which connects the axle to the frame, so arranged as to provide universal movement to compensate for road irregularities. This is accomplished by a heavy clevis member which fits into the frame bracket and is free to rotate, while its end fits into a slot in the radius rod, which is also slotted at its opposite end to fit over a lug on the axle. This method provides flexibility in any direction that the axle may move.

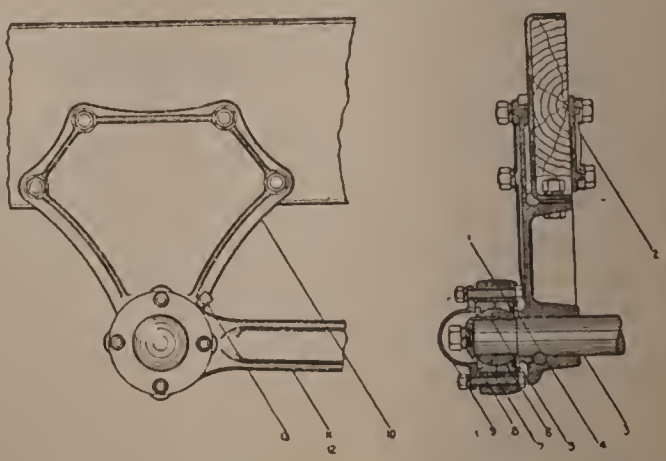

Fig. 50.—Sterling radius rod mounting.

A somewhat different method of accomplishing this is illustrated in Fig. 50, which is employed on

the Sterling trucks. It consists of a spherical member fitting inside of the radius rod, which provides a full universal movement. In either of the above cases the tendency of the axle to rotate, or in other words, the axle torque is resisted by the vehicle springs, which are made of such proportions as to perform this additional work.

In the Hotchkiss drive (Fig. 51) both of these functions are performed by the rear springs, which are rigidly connected to

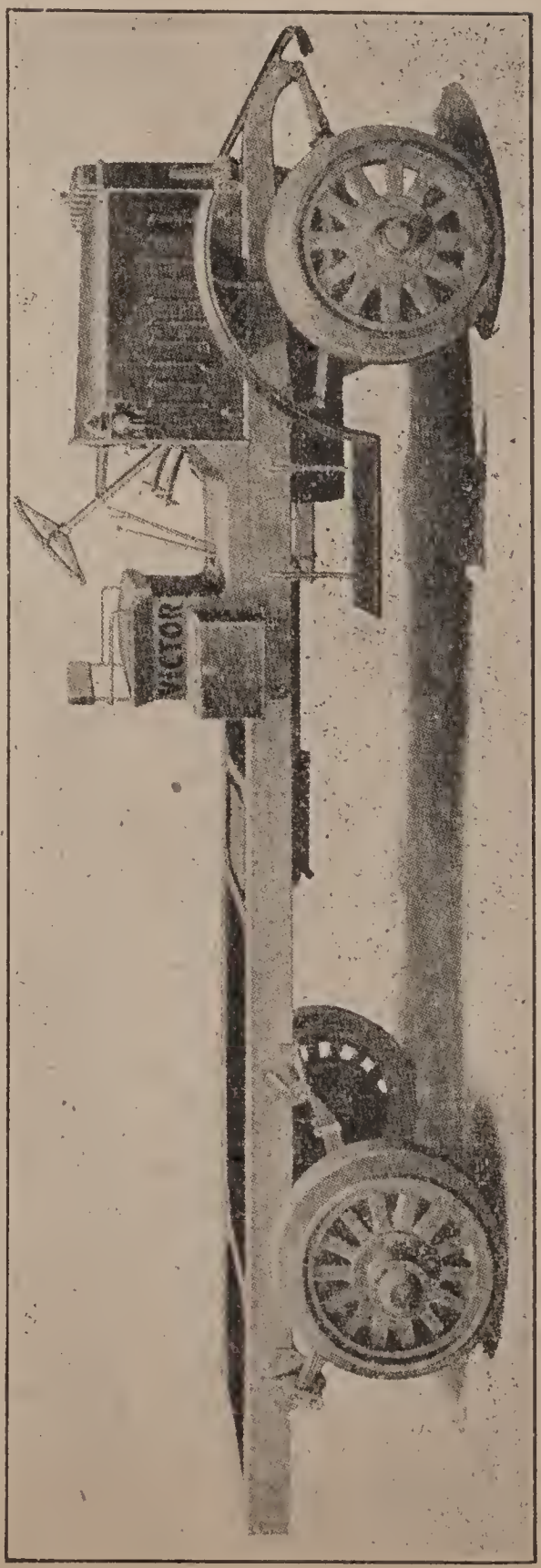

Fig. 51.—Illustrating the Hotchkiss type of drive.

the frame at their front ends. It has the advantage of being a much simpler and cheaper construction, and for vehicles of 2½ tons and under has proven to be a very successful method. In some respects this method has decided advantages, the principal one being that the shock of the load from the engine is cushioned through the springs before being applied to the tires, and this is claimed to increase their life materially.

Care of Axles.

As is generally the case with any motor vehicle unit, the principal item in the proper care of the axle is the lubrication. One should never make the mistake of using grease for this part, as was the case some years ago. Oil is the proper lubricant to use, for various reasons. It is also recommended by all makers of vehicles and by axle manufacturers. Once or twice a year the differential housing should be drained, and after being thoroughly flushed out with kerosene, fresh lubricant should be used. Note also that while the housing should be kept well filled at all times, an excess is not desirable, for the extra quantity may work out into the brakes and cause them to slip and not hold properly. Wheel bearings should be kept properly adjusted and lubricated. About twice a year the wheels should be removed and the bearings examined. If they are worn they should be replaced, as this is the safest and cheapest policy in the end. Wheel bearings should be lubricated with a light grease, which should be over and into the bearing surfaces, and the hub cap should also be filled with grease. There are also numerous oil and grease cups

about the axle which should have attention daily, unless the daily mileage is extremely low.

The brakes should be inspected at regular intervals and by all means kept in proper adjustment, so that they will not fail to function properly.

CHAPTER VI.

Universal Joints and Drive Shafts.

Types of universals, function of universal, solid and tubular shafts. Center bearing mounting. Propeller shaft brakes. Care of universal joints.

TO the lay mind, the necessity for universal joints in the final drive of a motor truck is not always apparent, although he is familiar with the fact that a shaft must be used to transmit power from one unit to another. At first glance it might seem that the shaft could be run in a straight line from the transmission to the rear axle without using any kind of universal joint; however, a moment's thought will show that this is impossible. The absolute necessity for a universal joint arises from the fact that the engine is mounted on the frame, and therefore moves up and down with the springs, whereas the rear axle follows the contour of the road. The result is the same as if the engine were stationary and the rear end of the drive shaft constantly moving up and down. Aside from this motion of the springs there is always a binding and twisting of the frame known as wearing, which alone creates sufficient mis-alignment to make a universal joint necessary. A rigid shaft would bind unless the alignment was perfect and provision made to prevent frame deflection. Perfect alignment is not an impossibility, but maintaining this alignment is, and for these reasons all shaft-driven vehicles are equipped with two universal joints, and many have three, especially when a long wheelbase is used.

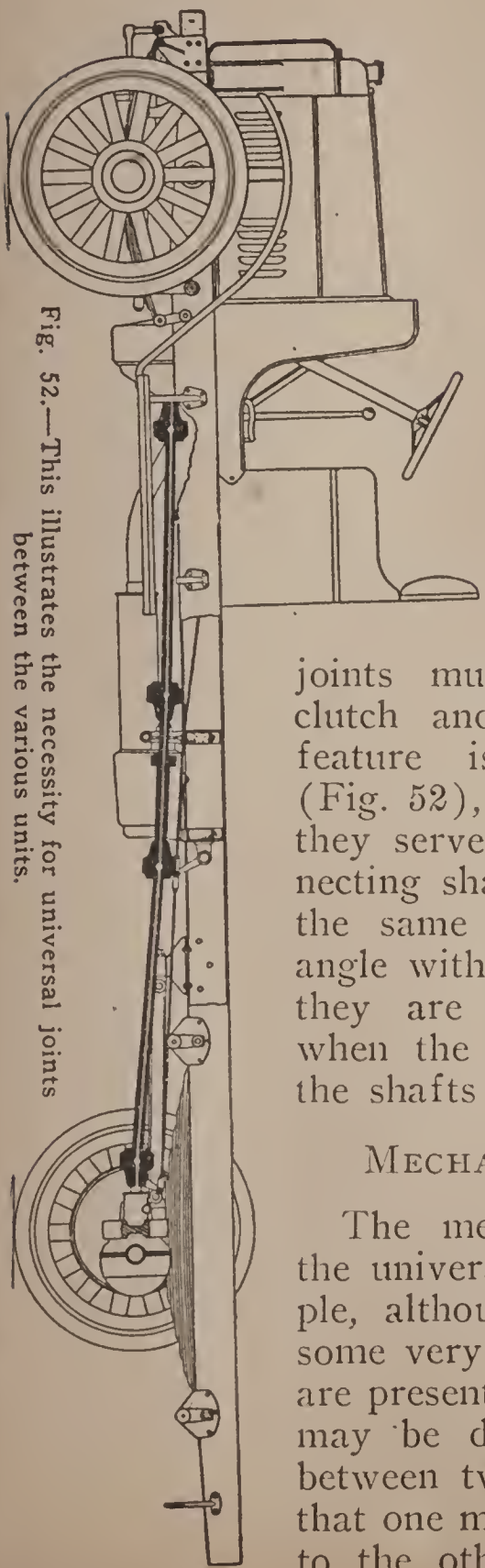

Fig. 52.—This illustrates the necessity for universal joints between the various units.

In some designs, the transmission is placed at some distance from the clutch and is not attached to the crank case of the engine. With this construction the wearing of the frame is sufficient to throw the transmission slightly out of line with the crankshaft, and for this reason universal joints must be used between clutch and transmission. This feature is clearly illustrated (Fig. 52), in that it shows how they serve the purpose of connecting shafts whose axis lie in the same plane, but make an angle with each other, and why they are particularly required when the angle varies between the shafts in service.

Mechanical Principle.

The mechanical principle of the universal joint is quite simple, although in its application some very complicated problems are presented. A universal joint may be defined as a coupling between two shafts endwise, so that one may give rotary motion to the other when forming an

angle with it and at the same time be moved freely in all directions. In the ordinary form of universal joint the ends of the shafts are forked and fitted over a central or connecting piece in the shape of a cross, with four arms of equal length and at right angles to each other. This construction allows the shaft to be moved freely in one direction within certain limits, and a rotary motion applied to one shaft is naturally imparted to the other. It can readily be seen that if the two shafts lie in a straight line they turn on the same axis just as one bar, but just as soon as the axis of one shaft is turned at an angle, the universal joints begin to function. It is evident, therefore, that the nearer the shafts of a motor vehicle can be kept in alignment, the greater efficiency will be obtained from the universals.

The drive shafts were originally made of solid sections, however, with the gradual increase in shaft drives and especially with the tendency toward unit power plant mounting of the transmission and long wheel bases, it became necessary to provide light shafts with a high factor of rigidity to overcome whipping when coasting at high speeds, so the tubular shaft became the standard type. The tubular shaft has another advantage, in that it reduces the pressure on the bearings due to the reduction in weight. There is a limit to shaft length, and when this is exceeded two shafts and three universals are used. In this case it becomes necessary to provide a bearing to support the rear end of the front shaft.

The power transmitting members are generally made of drop forgings, heat treated, and are accurately machined. The pins and bushings which form the bearings are made from low carbon steel, hardened and ground to close limits,

as very high bearing pressures exist when transmitting power on low gear. Steel stampings are generally used for housings to hold lubricant and the seal between the housing members is made of felt or flax packing. The hollow shafts are made from cold drawn .40 carbon seamless steel tubing. Various methods are employed in attaching these to the joints, which will be explained below.

Universal Joint Construction.

The universal joint in its elementary form is illustrated in Fig. 53, which consists of a center block with pins and two forked members which pivot on the pins and are spaced by the center block. Most universal joints incorporate this simple principle; however, details of construction vary considerably. This type of joint is still extensively used in the form illustrated on machine tools, while Fig. 54 illustrates another type which is also used to some extent on machine tools and was extensively used on the earlier models of shaft-driven vehicles and is today used on several foreign vehicles between clutch and transmission. It consists of a ball-shaped center member with four slots, into which the two yoke members fit. This is not adaptable to heavy loads, since there

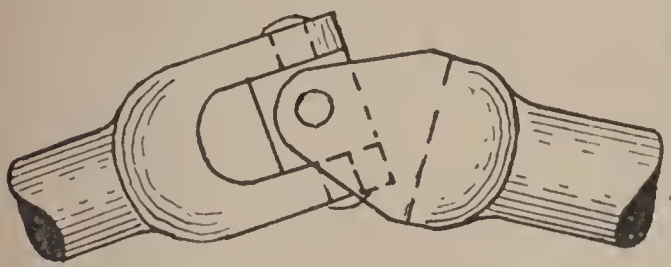

Fig. 53.—Illustrating the universal joint in its elementary form.

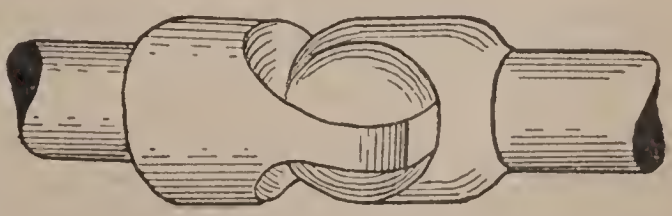

Fig. 54.—Spherical type of universal joint.

is but a point contact between the ball member and yokes. A little study of the above two illustrations will show how power is transmitted through two shafts which are at an angle to each other.

There are various modifications of the above types, and the principal features of these will be described and illustrated below. There are numerous features regarding their installation and maintenance which will also be described, since this unit, like all other units of a motor truck,

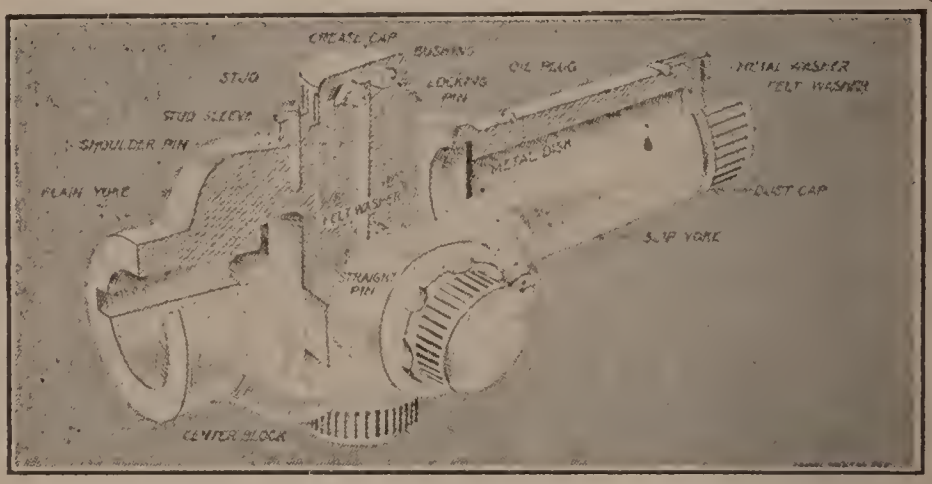

Fig. 55.—The Blood Bros. universal joint.

must be maintained at its greatest efficiency to avoid a loss of power.

The Blood Bros. Joint (Fig. 55) is similar to the elementary form described in Fig. 53. Briefly described it consists of two yokes or forked members connected flexibly by a cube usually termed a cross. This cross has two pins passing at right angles to each other, through the cross and pivot in bushing placed in the forked members. Each pin has two cups which enclose it and act as reservoir for the lubricant. Thus there are four points which must be lubricated in addition to the slip joint at the forward end of the propeller shaft.

Fig. 56 illustrates the Spicer joint, which differs from the above, in that the cube or cross is replaced by a spider which has four projecting pins which form the pivots. Two of these pins fit into bushings located in the flanged member which forms the driving member, while the remaining

Fig. 56.—The Spicer universal joint.

two fit into bushings located within the forked or driven member. This unit is enclosed within a pressed steel housing which is bolted to the driving member and also serves as a grease retainer. This housing is spherical at one end, so that another member carrying a packing can swivel about it. Since all pins and bushings are exposed to the lubricant within the housing, but one opening is required to introduce it.

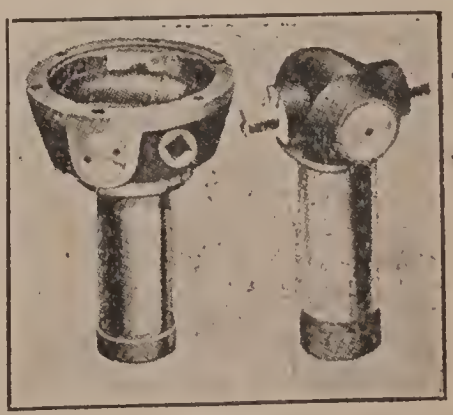

Fig. 57.—The Arvac universal joint.

The Arvac universal joint (Fig. 57) differs from those depicted above, as it consists of a ball yoke and socket fitted with a cross block and pins enclosed within a drop forged steel housing. This housing supports two bushings which provide the bearings for the king pin, thus providing a light but strong driving member of tubular section. The oblong space provided

within the housing forms pockets for the lubricant, which is oscillated by centrifugal motion, and this action forces the lubricant to all bearings. The yoke end is provided with a spherical surface, and this combined with a packing in the retainer forms a seal to retain the lubricant.

In any design the lubricant is acted upon by centrifugal force which forces it toward the walls of the housing, and if grease throwing is to be prevented, the seal must be of comparatively small diameter.

There are a variety of other designs which resemble the above types in some respect or other,

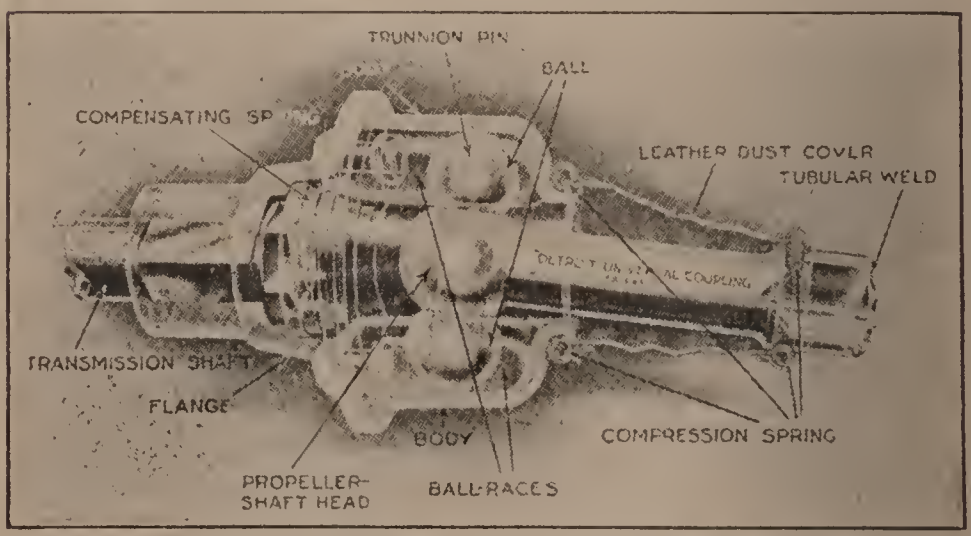

Fig. 58.—Detroit ball bearing universal joint.

but statistics show that the above types are by far the most popular.

There is another type which is popular on trucks of small capacity, particularly of one ton or under. This is illustrated in Fig. 58, and is sometimes called a ball-bearing joint, but this title is a misnomer. It consists of a pressed steel housing provided with two slots, into which are inserted two steel balls which pivot on a pin

passing through the driven member or propeller shaft head. A leather dust cover is employed to retain lubricant.

Propeller Shaft.

The drive shaft connecting the universal joints is generally called the propeller shaft, and this, as previously mentioned, may be made of tubular or solid sections. The former gives a maximum of strength with a minimum weight and consequently reduced whipping effect and pressure on the bearings. Various constructions are employed in fixing the tubular shaft to joints. In some designs the shaft is a shrink fit on these members and the joint is finished by welding. In the Spicer design the butt-weld is used, the two surfaces being electrically welded together, while in the Arvac design a neat combination of shrink fit and welding is used. The male members are provided with three keyways and shrunk into the tube, and the latter is crimped into these keyways and then the two units are welded together. In this method the driving thrust is taken by the three keyways and not upon the weld.

Propeller Shaft Mountings.

When two shafts are used a universal joint is generally attached to the transmission, thus supporting the front end of the forward propeller shaft, while the other end of the shaft is mounted in an anti-friction bearing, such as a ball or roller bearing. The center joint, which is of the slip type, is then mounted immediately back of this bearing. This construction is illustrated in Fig. 59, representing Nash practice. The bearing used is of the self-aligning type mounted in a housing which is bolted to a cross member of the frame. A shoulder on the shaft and a spring

type of washer between the bearing and universal joint flange hold the bearing in position, while its self-aligning feature and the end play allowed in the housing provide for frame deflexions and variations in shaft length.

Reason for the Use of a Slip Joint.

In any commercial vehicle at least two universal joints are used. In the rear position, that is, transmitting power from the transmission to the rear axle, one universal must always be provided with a slip joint or fitting, while in the forward position, clutch to transmission drive, a slip

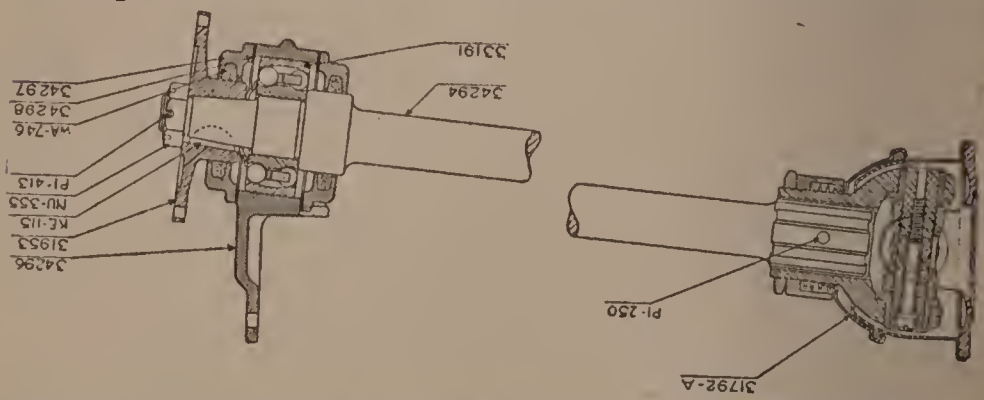

Fig. 59.—Nash center bearing mounting for three-joint shaft.

joint is used in some designs to compensate for shaft length variations and sometimes for clutch movement. It also presents an advantage in assembling. The slip joint in the rear must be provided to compensate for variations in the distance between the transmission and the rear axle, due to the play of the springs. The transmission under all conditions maintains a permanent relationship lengthwise with the frame, while the rear axle does not maintain a fixed relationship due to the action of the springs. Thus the propeller shaft must be capable of elongating, or shortening, and this feature is performed by the slip joint. This joint may either be a square or fluted shaft with a corresponding hub or sleeve.

Propeller Shaft Brake.

In some designs, one set of brakes are mounted in the rear wheels, which are usually used as the service brake, while the emergency brake is mounted on the propeller shaft. In this design the propeller shaft, universal joints and axle parts must be of sufficient strength to provide for the additional duty to be performed. This type of brake is illustrated in Fig. 60, and the claims generally made for it are, that it simplifies the

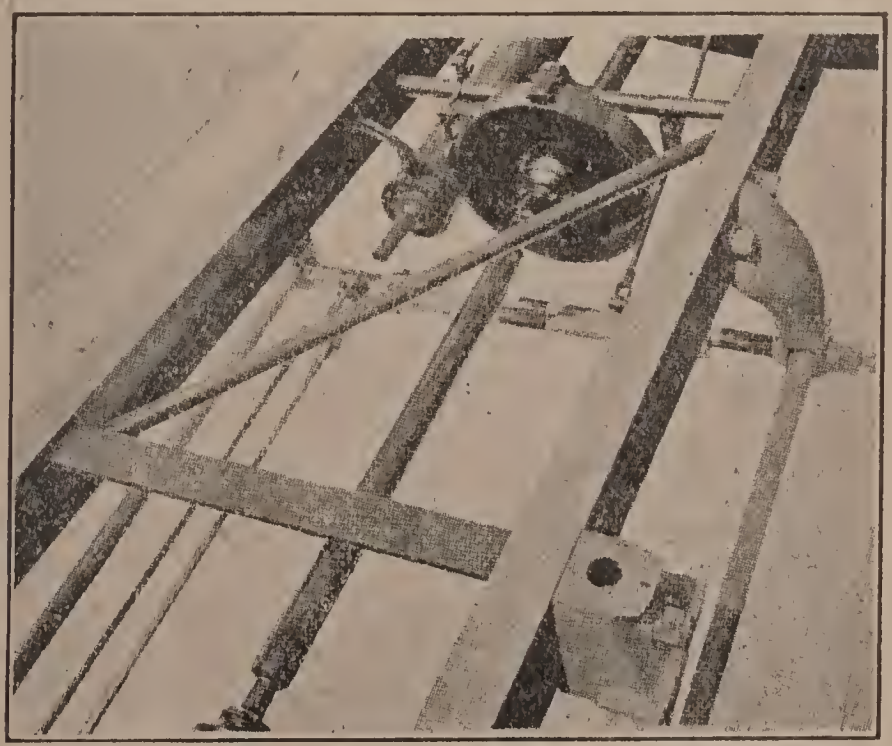

Fig. 60.—Propeller shaft brake.

construction, since a comparatively small brake drive can be used, due to the fact that the braking power is multiplied through the rear axle gear reduction.

Care and Maintenance of Universal Joints.

The universal joints are perhaps the most neglected unit of any vehicle, for there are many operators who do not even understand that such a

unit is incorporated in the power transmission system. The general practice recommended is to lubricate every 1,000 miles, the grade of lubricant depending upon the design, usually being recommended by the maker. Lack of proper lubrication rather than lack of quantity of oil in the joint is the cause of 99 per cent of all universal joint troubles. Use the proper kind of lubricant at the right time and in the right place. Thin oil or grease must be avoided, and thick grease cannot work into the bearings, hence a soft grade of grease is best.

The universal joints should be cleaned thoroughly several times during the year and then inject a small quantity of high quality steam cylinder oil, rotate the joints for several minutes to permit this oil to work its way into the bearing surfaces. Then add the quality of lubricant specified by the maker, taking care not to insert too much, since the excess will be thrown out rapidly. Two-thirds to three-fourths full is better than more. If the retainer is provided with adjustment, see that it functions properly, so that the lubricant cannot escape. Inspect the joints at regular intervals and keep all bolts tight. If wear is noticeable in the pins and bushings have these replaced immediately, for if this is not done, it will eventually mean replacement of the entire unit, which entails considerable expense. Bearing surfaces properly lubricated and in proper mechanical condition are absolutely essential, since the bearing pressures are necessarily high. Remember that a universal joint and propeller shaft is transmitting as much power as the transmission and rear axle, and yet only weighs about one-third as much as the transmission and generally but 10% as much as the rear axle.

To secure the highest efficiency and absence from vibration, care should be observed to have the pins at opposite ends of the assembly parallel, as this will eliminate vibration, which may become serious if the vehicle is driven at a speed high enough to cause the shaft to whip, as the velocity of the front joint must be equalized by the rear joint, since the velocity varies during each quarter revolution. Never operate the vehicle if the clutch is harsh, for this places a very severe shock load on the universal joints and in time will destroy the highly finished bearing surface.

CHAPTER VII.

The Steering Gear and Steering Linkage.

Various types of steering mechanism, drag links and steering connections. Care of steering mechanism.

THE steering gear is the mechanism used on motor vehicles to steer the pair of wheels which guide the vehicle. Most all vehicles are steered by the control of the front wheels, which are mounted upon steering knuckles on the front axle; the knuckles are held in position by a linkage connected with the steering gear. The axle knuckles are free to turn in the axle yokes about 35 degrees either way from the center line so as to allow the wheels to follow a curve when turning. The steering arms, which are keyed to the axle knuckles, are steel forgings, and one has an extension or integral arm which is used to connect the axle to the steering gear by means of what is termed a drag link. In order that the two front wheels may turn together, the steering knuckles are connected together by means of a tie-rod, which is usually of tubular construction and located back of the axle. This steering system is known as the Ackerman type and has been used for a number of years, and is the only type in use at present.

The steering mechanism of a motor truck, while apparently at rest when the vehicle is moving in a straight line, is constantly in motion because of its sensitiveness to even the smallest depressions and irregularities of the road surface. When the vehicle is traveling along what

appears to be a perfectly smooth course, the steering gear and all of its linkage is in motion, and it can readily be seen that these various parts are subjected to severe shocks and continuous strain and must be made of ample proportions.

The steering gear consists of a hand-wheel and column, a shaft enclosed in a mast and connected with some form of gearing which is located within a housing rigidly bolted to the frame of the vehicle. The principal difference of steering mechanism is in the form of gearing used. There are two general types, the worm and wheel and the screw and nut, the latter being the most popular type.

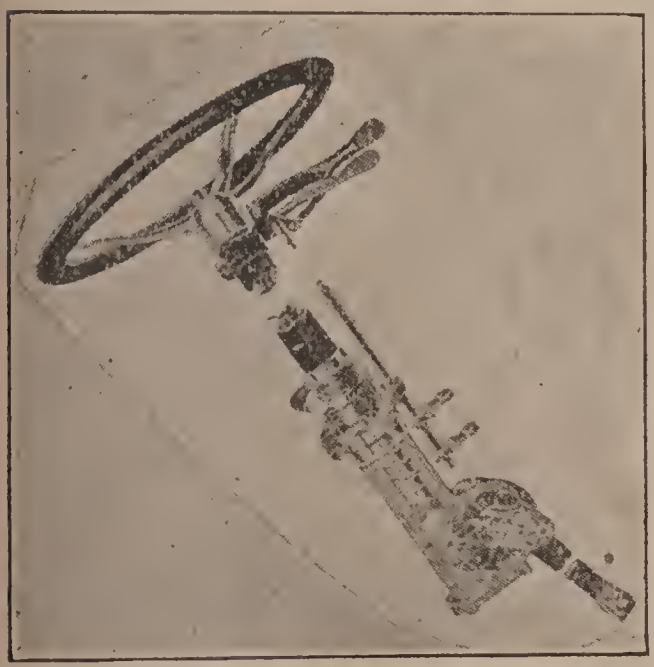

Fig. 61.—Ross screw and nut type of steering gear.

Screw and Nut Type.

Fig. 61 illustrates the Ross screw and nut type of steering gear, which is extensively used on vehicles of all capacities, being made in a number of models to meet the conditions of service of any vehicle. The construction of this gear is very simple. The means of securing the rotation between the hand-wheel and the steering arm is a screw having a very large bearing surface, supported between two thrust bearings to take up thrust in two directions; that is, the thrust acting two ways, up and down. This

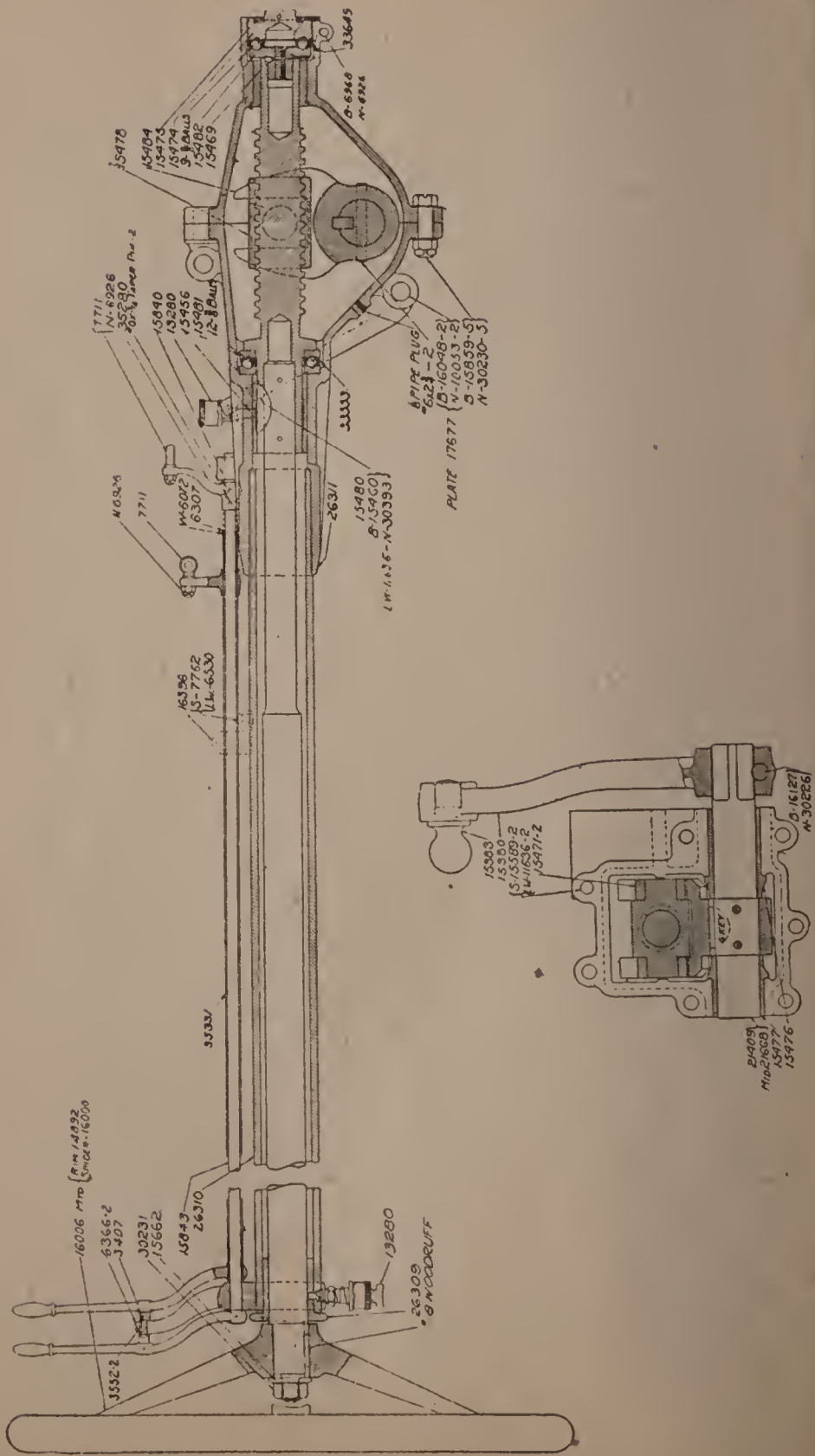

Fig. 62.—Pierce screw and nut type of steering gear.

screw is connected with the hand-wheel by means of a tube which is termed the steering column shaft. The block or sleeve into which this screw is threaded, and which travels longitudinally when the screw is turned, has longitudinal keys on its sides, which engage with corresponding grooves in the housing. The purpose of these keys being to prevent the block or sleeve from turning when the screw is turned. Obviously, when this occurs the block moves longitudinally. On each side of the lower end of the block or sleeve, cylindrical recesses are turned, and cylinders which are free to rotate are placed in the recesses. These cylinders have slots milled in them, which receive the protecting arms of a rocker shaft, which has the steering gear or pitman arm mounted upon it. Therefore, when the sleeve moves in the housing and carries the cylinders with it, these cylinders rotate, thereby rotating the rocker shaft and hence the steering arm.

Fig. 62 illustrates the screw and nut type of steering gear used on the Pierce trucks. The steering shaft has the hand-wheel keyed to its upper and a multiple square threaded screw at its lower end. This screw actuates a nut with trunnions on its outside which carry trunnion blocks that slide within the jaws of a forked lever, keyed to the steering arm shaft. The housing is divided and carries suitable ball thrust bearings, which are adjustable from the lower end of the housing. The operation of this gear may be explained as follows: Any movement of the hand-wheel turns the screw, and as the nut is prevented from turning by the yoke jaws and trunnion block, it is forced to move up or down and thus impart a rotary motion to the steering arm shaft.

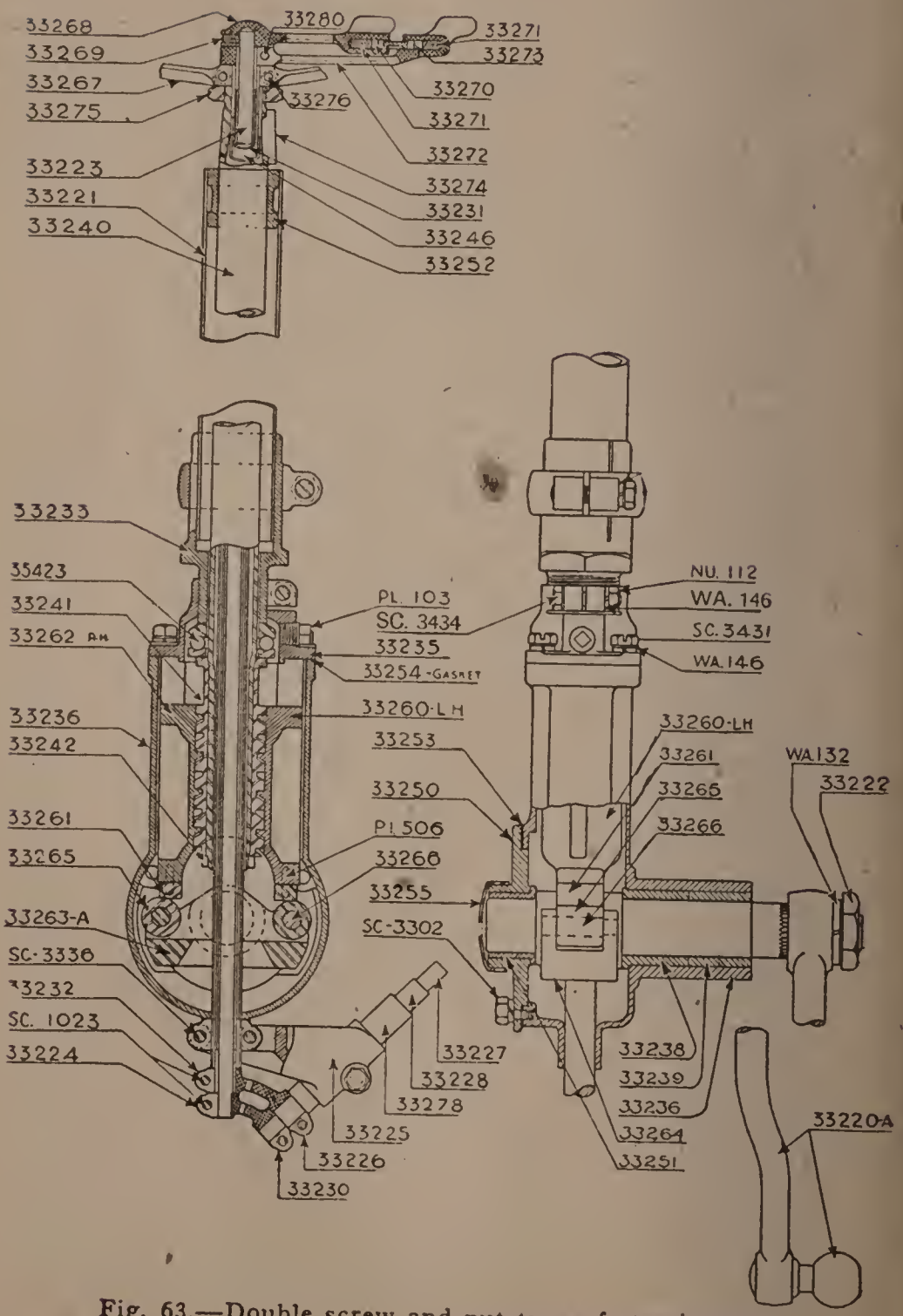

Fig. 63.—Double screw and nut type of steering gear.

Fig. 63 illustrates the double screw and nut type of steering gear used on the Nash, G. M. C. and other trucks. This is similar to those depicted above; however, the nut is made in halves and prevented from turning by lugs which fit in grooves formed in the walls of the housing. These nuts are made with right and left-hand threads, and moving the hand-wheel causes one to move up and the other down. The ends of these nuts bear against rollers mounted in the steering gear yoke, which is integral with the steering arm shaft, and any motion applied to the hand-wheel causes the nuts to impart limited rotary motion to the steering arm shaft.

Worm and Wheel Type.

The worm and wheel type of steering gear is illustrated in Fig. 64. A worm is attached to the steering shaft which meshes with a worm wheel mounted on the steering arm shaft. Turning the hand-wheel turns the worm, which in turn operates the worm wheel, shaft and steering arm. A feature of this type is that, as only about 90 degrees of the worm

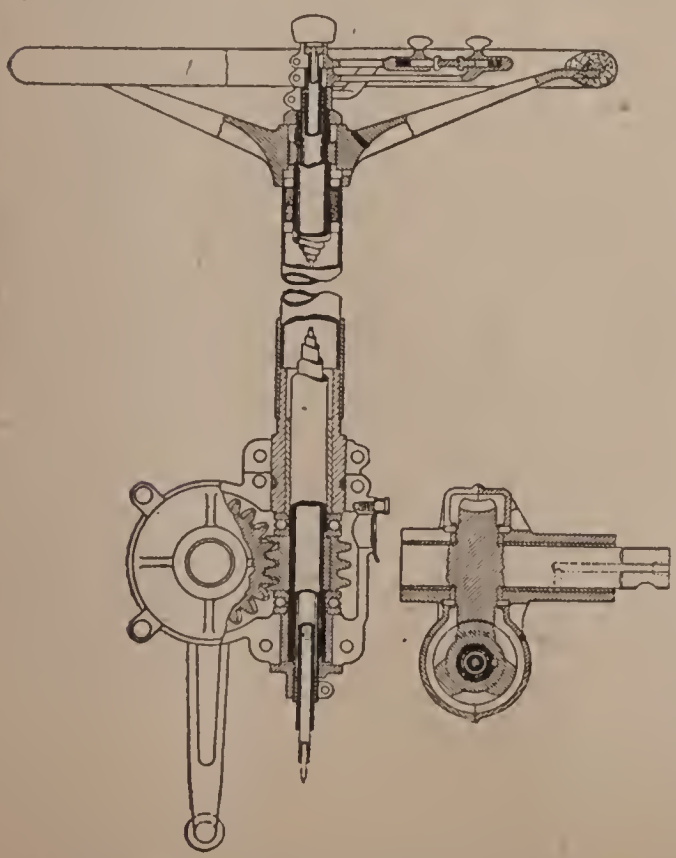

Fig. 64.—Warner worm and wheel type steering gear.

wheel comes in contact with the worm teeth, while the road wheels are moved through their entire turning range, and as the shaft carrying the steering arm is squeezed, this arm can be removed and wear taken up by turning the wheel through an angle of 90 degrees, thus bringing another quarter-section into action.

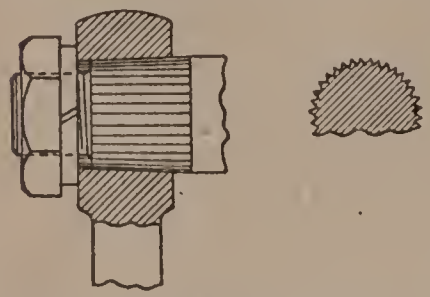

Fig. 65.—Method of locking steering arm with taper and serrations.

Another method of attaching the steering arm to its shaft is illustrated in Fig. 65. In this the end of the shaft is tapered, while the shaft and lever are serrated, the effect being a large number of keys and grooves which are drawn tightly in mesh by means of the taper and a lock-nut.

Drag Links.

The drag link, which connects the steering arm with the lever or the steering knuckle of the axle, is shown in Fig. 66. It has ball and socket joints which fit over the ball surfaces of the steering levers. The ball sockets are removable, so that they may be replaced when

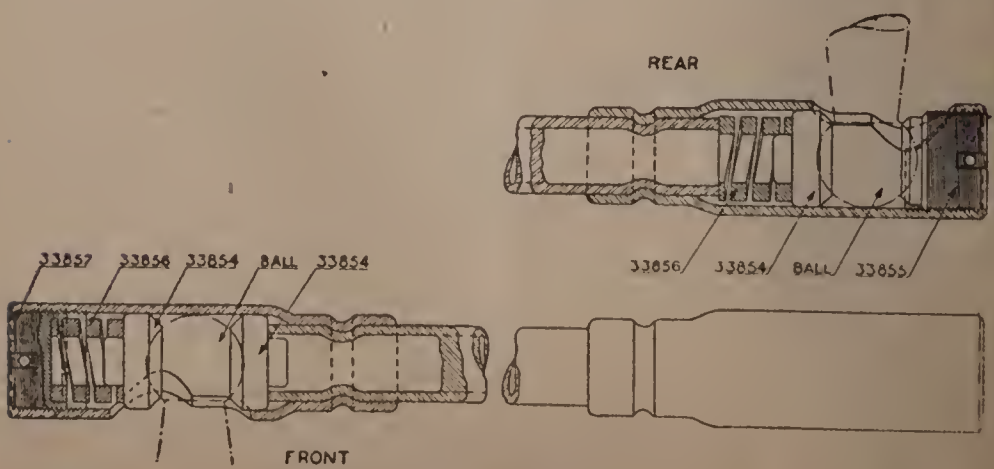

Fig. 66.—Drag link construction.

worn, and in order to reduce the shock on the steering mechanism heavy coiled wire springs are placed in each end of the drag link. Each end is provided with a nut to take up wear and for spring tension adjustment. These ball and socket joints are in effect universal joints, which are necessary, because the steering arm works in a vertical plane and the knuckle arm in a horizontal plane.

An important point in the layout of the steering mechanism is the desirability of a proper geometrical layout for the drag link, to avoid

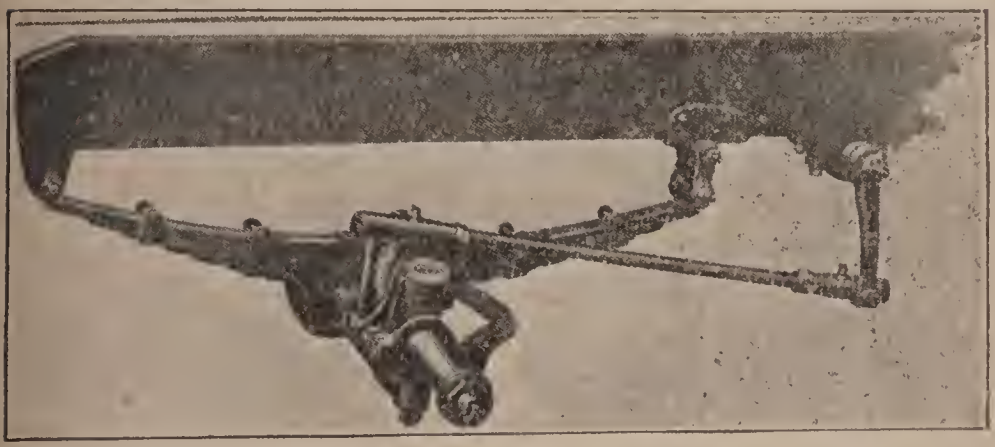

Fig. 67.—Illustrating connection between steering gear and front axle.

front wheel wobble under front spring deflexion when the vehicle is in motion. In other words, it is very important to have the drag link so arranged as to produce the least tendency to rotate the steering gear arm as a result of the action of the front springs. In order to illustrate this feature, Fig. 67 is presented, and it will be noted that if a straight line is drawn through the front eye of the spring and the center of the steering arm, it will intersect the center of the ball on the knuckle arm. Under this condition the least amount of motion will be transmitted to the steering arm.

In order to prevent road shocks from being transmitted to the operator's arms, it is considered best to have the steering gear back-locking, or irreversible, to some extent at least. With a perfectly reversible system it is evident road shocks which are transmitted to the operator's hands depend on their magnitude and the lever arm through which they act. Practically all steering gears are made irreversible to some extent.

Care of Steering Mechanism.

The lubrication and adjustment of steering apparatus, usually neglected, is as necessary and as important as the oiling of the motor, the adjustment of the clutch, or any other vital part of the vehicle. Lubrication of the steering mechanism is a simple matter, requiring the use of oil and grease in perhaps five or ten different locations. Failure to lubricate the motor may mean a loss of money because of injury to parts, but failure to care for the steering gear may mean a loss of life, which cannot be replaced at any price.

On the front axle and steering connections will be found a number of small oil or grease cups. Frequently these jar loose and are never missed, and the holes are exposed to water and dirt which works into the bearing surfaces. Every truck driver knows, or should know, that a grease cup should be turned regularly, and the sooner he finds out when each cup needs attention, the sooner the maintenance cost will decrease.

The lubrication of one type of steering mechanism will serve to show just what parts require attention and the frequency with which they should be oiled and inspected. The steering column proper is usually provided with a small

oil cup over the wheel to oil the upper bearing for the shaft, while at the top of the housing is a cup for oiling the lower bearing. For both of these a light oil is generally recommended. The housing proper is provided with an oil plug, which should be removed at regular intervals, about every four to six weeks. Heavy oil should be injected and this will serve to lubricate the enclosed mechanism. The drag link, if provided with grease cup, should have at least one turn every day, and a refilling of cups about once a week. This also applies to all other cups on the steering linkage and front axle. If oil cups are provided instead of grease cups, they should be filled daily, and if the vehicle is used for long overland hauls, it may be advisable to fill them twice daily. All steering gears are provided with some form of adjustment to take up play in the hand-wheel, which should be taken up as soon as it becomes evident that wear is taking place.

Adjustments in the drag link or steering linkage can be made by removing the cotter pins which lock the end plugs in position. These may be drawn up to take up any wear in the ball and socket joints. Wear in the knuckle levers can usually be taken up by drawing up on the nuts which retain them or by placing washers in back of them. It is difficult to provide a take-up for wear in the king bolt about which the knuckle pivots, and also in the cross-rod bearings, and it usually becomes necessary to replace these when wear sets in.

In making adjustments and in lubricating the steering mechanism, one should be sure to follow the instructions given in the instruction book which is supplied with every vehicle. If this has been misplaced, a copy can usually be secured gratis from the maker of the vehicle.

CHAPTER VIII.

Springs.

Construction, mounting, lubrication and maintenance.

THE chassis frame, which supports the body and power transmitting units, is mounted upon the axles through the intermediary of steel springs. These springs are built-up of a number of leaves or plates varying in length, and are used on all vehicles. These springs are intended to compensate for the unevenness of the road surface and they must also serve to protect the frame and other units, as well as the load from severe shocks, thereby preventing breakage and delaying crystallization. They also materially assist in increasing the life of the tires, by relieving them of the severe thrusts of lifting the machine instead of the wheels and axles alone. Flexibility and strength are also factors, as shocks due to uneven road surfaces are frequent and severe.

The upper leaf usually has an eye at each end for connection to the spring brackets on the frame, or shackles. In some cases one or both ends are left flat and bears against brackets on the frame. The balance of the spring consists of a number of leaves, the lengths of which decrease uniformly. Some method is usually provided to hold them together at their center and the eyes are usually provided with removable bushings, so that they may be replaced when worn. The frame connection depends upon the type of spring and various other factors, while the axle connection is usually made by box clips and a spring seat on the

axle. These springs in most cases also serve as a tractive medium, pushing or pulling the axles, which results in an additional strain.

Spring Type.

Motor truck springs, as far as the type is concerned, have practically been standardized and on what is termed the semi-elliptic type. This is the simplest type, and all other types are made up wholly or in part of the former. The principal difference in spring suspensions is not in the type of spring, but in its mounting under the frame and on the axle.

The material used in the construction of springs and its heat treatment are of the utmost importance, the materials generally used being carbon steel, silico manganese, chromium alloy and vanadium steels. Carbon steel is popular, however, by using alloy steels much better results are obtained as regards resiliency and strength are concerned, and fatigue and breakages are greatly reduced. The difficulty with alloy steel lies in its heat treatment, which must be exact in order to obtain satisfactory results.

The spring leaves are tempered or hardened by first heating them to the proper temperature and chilling them in an oil bath, and afterwards drawing them to the proper degree of hardness in one or more furnaces which are regulated by pyrometers.

Rebound Clips.

All springs are provided with rebound clips, the purpose of which may be explained as follows: When the road wheel strikes an obstacle in the road the spring near it is compressed, whereby energy is stored. Immediately after the compression has ceased the spring distends again,

and if the blow was a heavy one the rebound will carry the body far beyond its original position. This rebound has a tendency to curve the main leaf of the spring in the reverse direction, and in order to prevent breakage or any serious difficulty it is necessary to transmit this shock to several of the leaves. This is accomplished by the rebound clips, illustrated in Fig. 68. These, it will be noted, are riveted to the shortest leaf which they surround and are connected over the main leaf with a bolt, so that a shock caused by the rebound is distributed over a number of leaves.

Although the clips which hold the springs to the axle seat tend to hold the leaves in alignment, they alone are not sufficient, and in order to prevent lateral motion of leaves, some other provision must be made. The rebound clips assist in holding those leaves which they surround in alignment and are frequently depended upon for this purpose. In some cases lips are provided on the leaves near their ends, while in others slots and depressions in alternate leaves are used.

Fig. 68.—Conventional type of semi-elliptic spring, showing method of attaching rebound clips.

Spring Mounting.

Various methods have been devised for lubricating the spring leaves; in some cases small ducts are formed in the leaves which are intended to retain the lubricant which is placed between the plates when they are assembled. On several vehicles, the leaves of the spring are rolled thin in the center along their whole length, the outer

edges only coming in contact, as shown in Fig. 69. This allows a small space through which the lubricant works between the spring leaves.

Fig. 70 illustrates the sterling 3½-ton front spring mounting which is of conventional design. The spring is rigidly attached to the spring horn at the front end of the frame by means of a shackle bolt fitting in the bushing of the front eye. At its rear end it is attached to the frame bracket by means of shackles and shackle bolts, which are so arranged as to pivot and provide for the elongation of the spring under load. Near its center it is attached to the spring seat on the front axle by means of box clips and nuts bearing against a pressure plate over the top leaf of the spring. Front springs are generally made as flat as possible, as this gives the minimum shackle movement which is quite desirable, while good steering also demands a flat spring, as this decreases the tendency of the front wheels to change their line of travel. The construction of the shackle is shown in the inserted

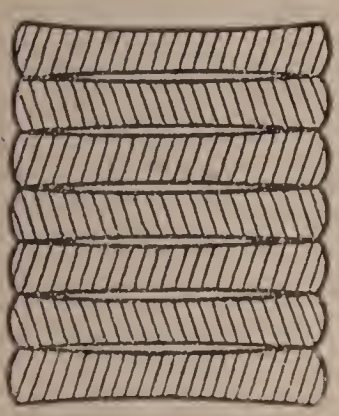

Fig. 69.—Method of providing space between leaves for lubricant.

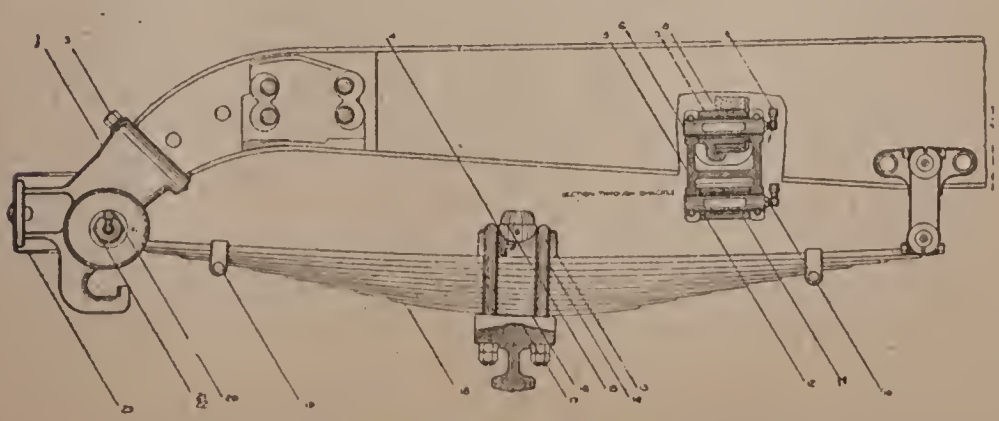

Fig. 70.—Conventional front spring mounting.

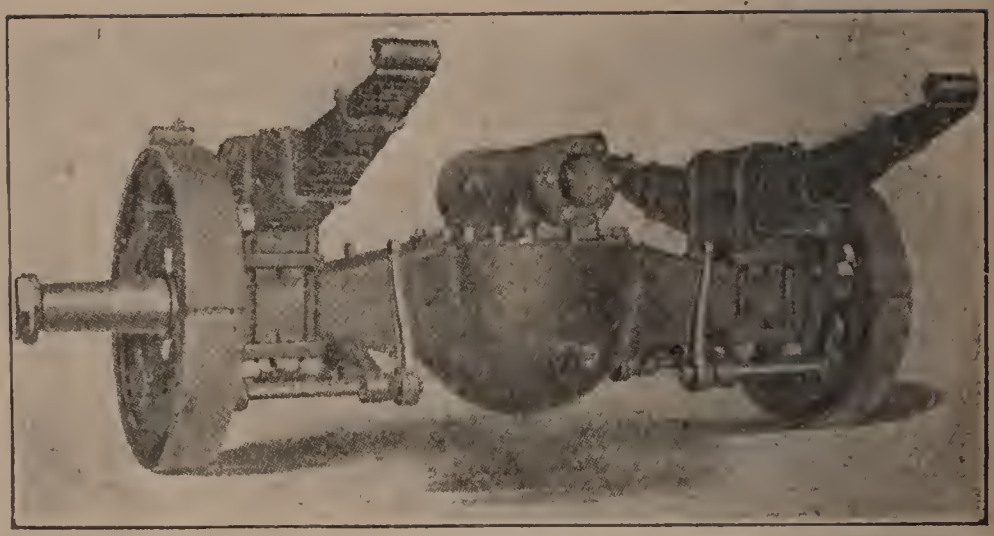

Fig. 71.—Conventional method of attaching rear springs to their seat on the axle.

sectional view, the shackle bolts being fixed in the eyes of the shackle while they are free to pivot in the bushings, in the spring eye and the frame bracket.

Fig. 71 illustrates the method of attaching the rear springs to the axle. A heavy pressure block is placed over the top leaf of the spring and the clips, which are of U shape, extend through both upper and lower pads of the axle housing. This construction is ordinarily used when radius rods

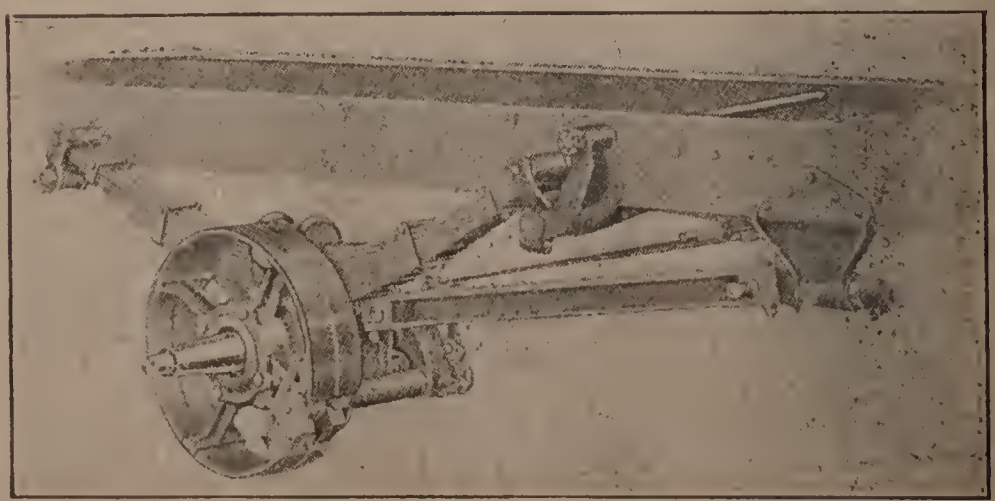

Fig. 72.—Spring mounting, using radius rod to take the thrust of propulsion.

are provided to take the thrust due to the propulsion of the vehicle. However, additional means are provided when the Hotchkiss type of drive is used, which will be explained later.

Fig. 72 illustrates the method of shackling both ends of the spring in this case, either end of the spring being free to elongate while the radius rod controls the relation of the spring longitudinally with the frame. This is the conventional type of mounting used for this type of drive and illustrates the construction used on the Indiana trucks.

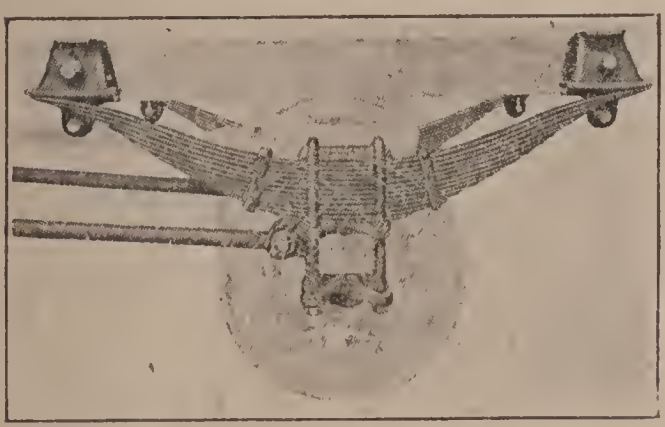

Fig. 73.—Armleder spring construction. Plain ends are used which bear against brackets on the frame.

The rear springs of the Armleder truck (Fig. 73), which also employs radius rods to take the thrust due to propulsion, differs from the above in that the springs have plain ends and are not shackled to the frame. The ends of the spring bear against brackets riveted to the frame and the center distance upon which the load is applied, regardless of the camber of the spring, is always the same. Thus as the springs flatten, due to the load of the vehicle, instead of the upper leaf carrying the load, several leaves are used, thus materially strengthening the main leaf. With this construction some provision must be made for the side thrust of the axle, and this is accomplished by lugs extending from the frame brackets, which hold the springs in alignment with the frame.

The spring mounting for the Hotchkiss type of drive is illustrated in Fig. 74, and it will be noted that in this case the front end of the spring is rigidly attached to the frame bracket while the rear end is shackled, the mounting being almost identical with that of the conventional front spring. In this type of mounting some provision must be made to prevent any possibility of spring slippage, due to the thrust of propulsion. Spring breakage is also frequent unless the spring clips and pressure blocks are of liberal proportions.

Some excellent features have been developed lately which show how the problems connected

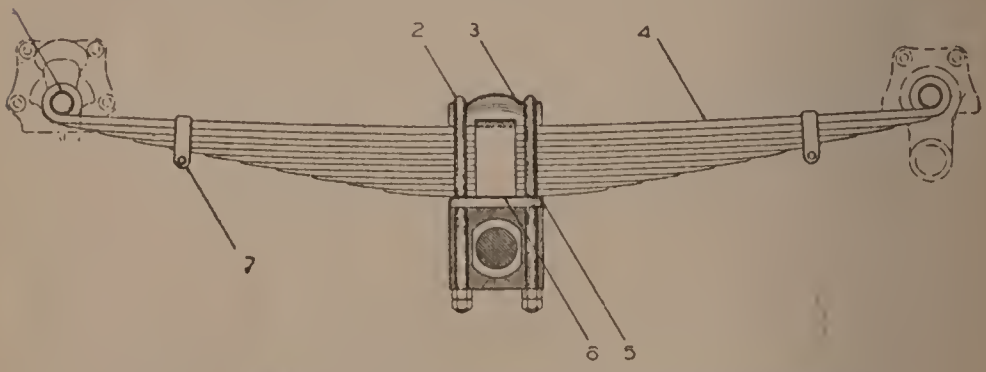

Fig. 74.—Rear spring mounting for Hotchkiss drive.

with this type of drive have been solved. Nickel steel spring clips are used by many, while others are providing rigid anchoring of the springs to the axle in various ways. As flat springs must be used, this necessitates a rigid anchorage to prevent the pressure blocks from creeping. On the Winther trucks a particularly rigid anchorage is used. This is shown in Fig. 75, and consists of a special casting which fits the spring snugly, one-half being combined with the pressure block, while the other half is combined with the spring seat. On the vertical sides of each of these castings are heavy shoulders, bearing against the spring clips and so preventing displacement. This feature of keeping the spring clips at right angles

to the spring leaves is an essential of this type of drive. The Service, Diamond T, United States and other trucks are provided with similar arrangements.

Those makers who do not provide any special anchorage give special attention to have the

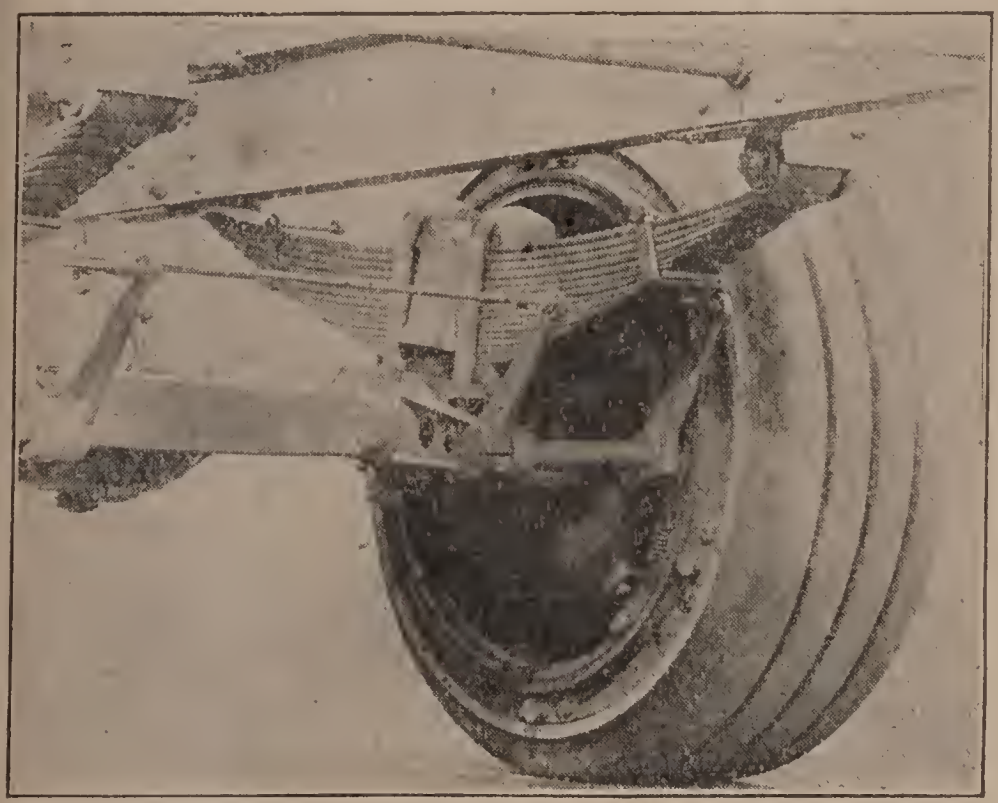

Fig. 75.—Illustrating the Winther method of providing a rigid anchorage for the springs.

spring anchorage as rigid as possible with the use of a specially flat spring with heavy upper leaves. Spring seats are usually machined to fit the center of the spring and all points of contact are carefully white-leaded so that both air and water are kept out of the joints.

Shackle Bolt Lubrication.

These shackle bolts work continuously in the bushings of the springs and brackets and will wear quickly if they are allowed to remain dry.

Lubrication is either affected by grease or oil. In order to simplify maintenance some makers provide what is known as a magazine oiling system as illustrated in Fig. 76. This, we believe, was first introduced on the Military Class B truck and has since been adopted by several makers. It consists of oil reservoirs cast intregal with the shackles, oil being fed through wicks by means of capillary attraction to the various bearings.

In some cases, reservoirs are provided in the shape of an annular space between the bushings and its supporting element. A lubricator is used for filling and a wick is so placed that as the motion of the truck agitates the oil, the wick becomes saturated and so feeds oil to the bearing surfaces. In either system lubrication stops as soon as the vehicle stops, and the amount of lubrication will be in direct proportion to the amount of vibration or movement of the shackle, which is what is claimed to be required.

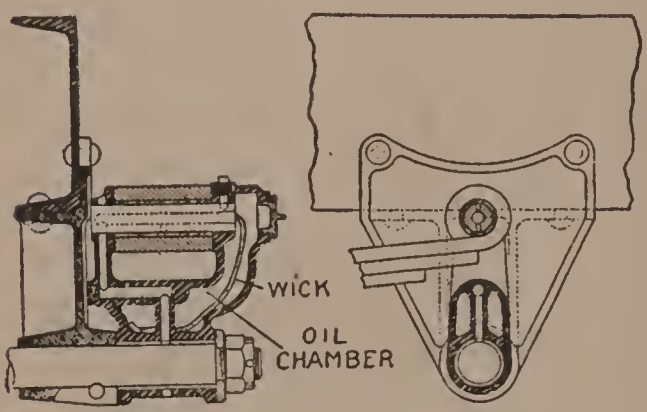

Fig. 76.—Magazine oiling system for spring shackles.

Where grease is used as a lubricant, pressure nipples are sometimes provided in the shackle bolts. These nipples are then connected with a high pressure grease when lubricating is done, which forces grease to the bearing surfaces under a considerable pressure and also drives out the old accumulations.

Care and Maintenance of Springs.

Motor truck springs are a very badly neglected unit, the vehicle is overloaded far beyond the capacity of the springs, while they never receive the slightest amount of attention. Springs, no matter of what type or grade of material they may be made from, will give trouble if they do not receive proper attention. It is very important that the nuts on the spring clips, which hold the springs in place on the axle seat, should be kept properly tightened. If this is not done, it allows the spring to work loose, and in time this may be the cause of spring breakage.

A point not always observed by the new driver is that it is necessary in a new truck to tighten these clips. Though the clips are tightened firmly when the truck leaves the factory, the continual working up and down of the spring leaves will cause them to set gradually, thereby somewhat loosening the spring clips. The clips should by all means be drawn tight every once in a while. Spring breakages are mostly due to loose clips.

Even the best designed springs will become squeaky as soon as moisture enters between the leaves and causes rust. The best way to lubricate the leaves without removing them from the truck, is to lift the truck by placing a jack under the body. Remove the bolts in the rebound clips to allow the weight of the wheels and axles to pull the spring leaves apart so that it is possible to insert graphite and grease between them. Graphite grease is preferred, because the graphite will remain between the leaves and continue to act as a lubricant long after the grease itself has become dry. A spring treated this way may not require attention more than twice a year.

Any one who has had experience with machinery having moving parts can readily appreciate the necessity of keeping a part working easily in a bearing. It will be observed that there are other parts about the springs besides the leaves which require attention. Spring shackles and bolts also require attention, as they are necessary in order that there may be room for the flattening of the spring when loaded. In other words, the shackles are a free joint between the spring and the frame.

To minimize friction and to prevent excessive wear of the shackle, links, spring eye bushings and shackle bolts, it is necessary to provide an ample supply of lubricant at all joints. Very rarely do these parts receive the attention they should in comparison with the duties they perform. The results of neglecting these parts are excessive wear, and often breakage. These troubles can easily be prevented by proper lubrication, and an occasional inspection and tightening of the nuts on the spring shackles.

CHAPTER IX.

Wheels, Rims and Tires.

Wood and steel wheels. Solid and pneumatic tires.

THE road shocks of a vehicle are absorbed by the tires through the rim and wheel and thence distributed, spreading out in all directions from the hubs of the wheels. Motor truck wheels may be divided into two major classes—wood and steel.

Wood Wheels.

The predominating type of wheel of the past has been the wood artillery type. This type consists of spokes made from very tough wood, generally second growth hickory, and differs from the horse-drawn vehicle wheel, in which the ends are mortised into a wooden hub. In the artillery type of motor truck wheel, the inner ends of the spokes are wedge or sector-shaped and so proportioned and formed that when the spokes are assembled in the felloe and on the metal hub, their sloping sided ends fit tightly together, filling the entire angular space and forming a compact wooden disc with a hole in its center filled by the metal hub. The compactly arranged inner ends are clamped between two steel flanges, one integral with hub and the other separable, by means of bolts passing through the two flanges, and through each of the spokes. The felloe is reinforced by the rim which supports the tire.

The wood type has spokes and felloes made

from well-seasoned timber, so that strength and toughness in the highest degree can be obtained. Second-growth stock and stock from the lower portions of small trees yield its best parts. The wood is cut when all the sap is out of the tree, which in some parts of the country makes the cutting season very short.

Wood wheels to withstand the heavy duty imposed upon them in motor truck service must be correctly designed, and while there is no definite method of calculating the proportions, makers as a rule have provided a successful construction by considering past experience and providing a considerable number of spokes, which are so proportioned that they have a considerable bearing in the hub and against the felloe.

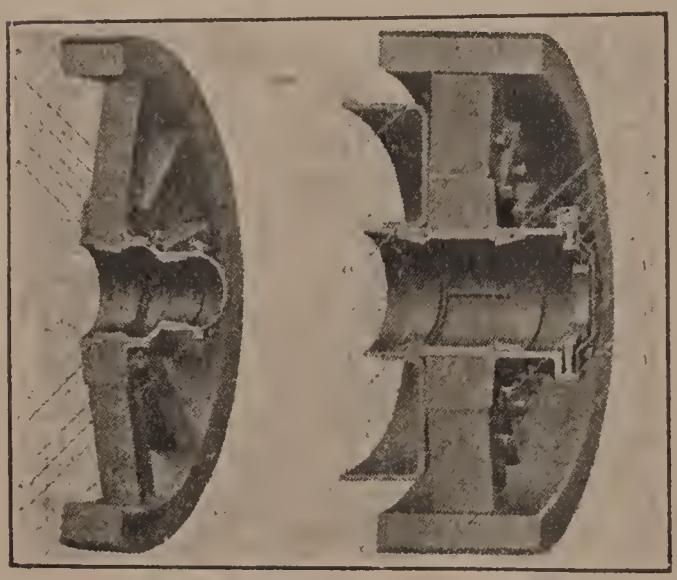

Fig. 77.—Front rear wheels of the Packard truck.

Fig. 77 illustrates the front and rear wheels used on the Packard trucks. The view at the left illustrates the front wheel; the spokes are of approximately square section and the method of supporting these in the felloe is clearly illustrated. The view at the right shows the rear wheel, which is of much heavier construction. The spokes are supported by the hub flange and the brake drum, and they are made of rectangu-

lar section. The felloe in each case is reinforced by the steel band upon which the tire is pressed.

Steel Wheels.

Steel wheels are now gradually coming into use, particularly on vehicles of 3½ tons capacity and over. The advantages of this wheel over the wood wheel are strength, true shape, rigidity, concentricity of hub and accurate design for the support of the load. In point of strength and resiliency, the steel wheel is well made, is superior to the wood wheel, and will sustain more impact and side thrust. Another advantage is that they may be accurately machined, and once round, they stay so, regardless of humidity, heat, etc., that affect most wood wheels. There are a number of parts, such as the brake drum and hubs, that may be cast integral with the wheels, thus eliminating the danger of loose parts due to bolts or rivets loosening under the constant vibration. The advantage of having wheels complete and ready for mounting is considerable; however, they are made in one piece, and therefore cannot be altered for different types and sizes of tires as easy as a wood wheel, and a spoke in a wooden wheel if broken can be replaced, but not so with the steel wheel, as in case of accident the entire wheels must be replaced. Any casting is also liable to contain flaws and blow-holes, while unequal sections will cause local variations in strength and internal stress in the castings due to shrinkage.

Steel wheels vary considerably in construction, and opinions differ as to which construction gives the best service. There are two types, both of which have their advantages and disadvantages. Some manufacturers favor the spoke type, which

is similar in appearance to the wood wheel, while others favor the single or double disc type.

Fig. 78 illustrates the hollow spoke type of wheel, which has been very popular, although it is somewhat heavier than the disc type illustrated in Fig. 79. The variety of wheels offered indicates that manufacturers cannot agree upon any type, although all types may be said to be equally successful. Time alone will prove the advantages of any particular type.

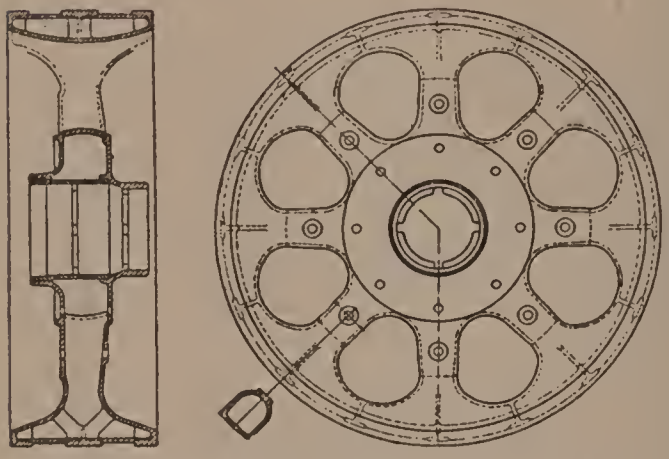

Fig. 78.—Spoke type of cast steel wheel.

Duty of Wheels.

The majority of vehicles are driven through the rear wheels, and the duty of the front wheels is limited to fixing the direction of the vehicle, aside from the question of acting as rollers, which is common to all road wheels. Driving movements are not engendered, because there are no twisting movements of the character which must be borne by

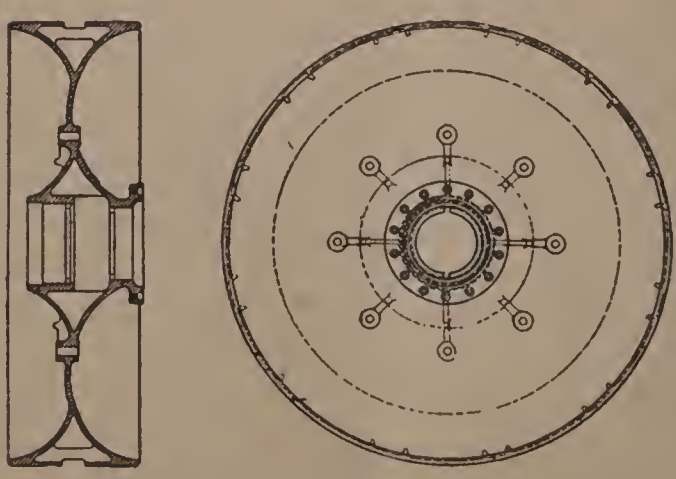

Fig. 79.—Disc type of cast steel wheel.

the rear wheels, and the spokes are therefore reduced in section accordingly. The rear wheels must propel the vehicle, resist the brake effort and be capable of standing excessive lateral strains in skidding.

Care of Wheels.

A wheel can hardly be considered as being subject to damage or depreciation from use unless the vehicle has skidded into a curb, or hit some obstacle which will tend to knock the wheel out of true or break the spokes.

In some cases, after a vehicle has been used for some time, considerable shake or looseness may exist between the hub and flange, as well as between the spokes themselves. It is therefore essential to keep all bolts tight, and the ends of the bolts should be riveted over to prevent vibration from working the nuts loose.

Painting of wheels is another important factor, and care should be exercised to see that they are always properly covered. This is especially true of the wood wheel. Another point which is often neglected in the effort to secure better tire mileage, is the practice of runing on badly worn or cut tires.

Rims.

Tire rims or metal bases and wheel filler bands are usually made from flat stock and rolled to shape, and the ends are then welded together. Special machinery is used for this purpose, and each band must check within certain limits. Pneumatic and demountable solid tire rims are made in a similar manner and must also be within certain limits. Little need be said of this subject, as most everyone is familiar with it.

However, for the benefit of those who are not

familiar, reference may be made to Fig. 77, which illustrates the plain band rims for solid tires, while Fig. 80 illustrates the various parts of the pneumatic tire rim. The latter is identical with the passenger car type, with the exception that the parts are heavier. Pneumatic tires are, as a rule, not absolutely puncture-proof, and it therefore becomes necessary to provide some form of demountable type of rim, so that the tire may be removed when necessary.

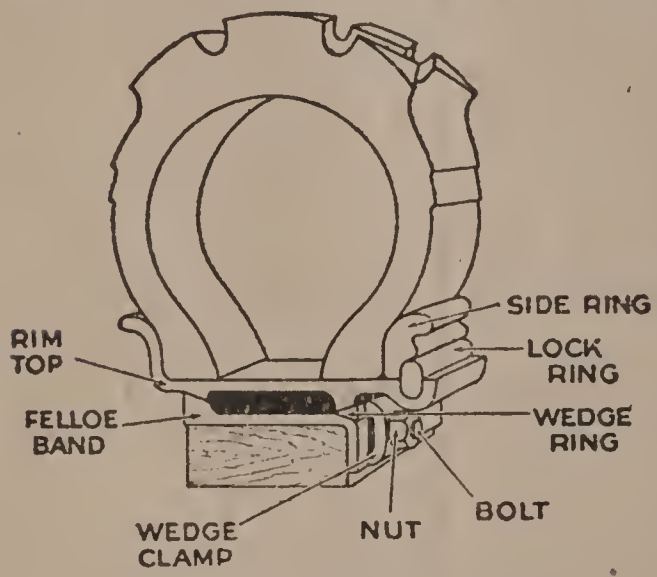

Fig. 80.—Pneumatic tire rim.

Motor Truck Tires.

A tire consists of a continuous or sectional band of metal, covered with a rubber compound, and generally used to form a shock-resisting element and to provide a suitable means for traction. There are two types of tires—the solid and the pneumatic type. The latter type has recently become popular on motor trucks, owing to its various advantages over the solid type of tire.

Solid Motor Truck Tires.

The modern solid tire is generally of the pressed-on type, which has proven highly satisfactory for all conditions of service, except when high speed is necessary. It is the outgrowth of the horse-drawn vehicle tire. This tire consists

of a compound of rubber and other substances, which is built up in layers and graduated in consistencies, from a hard rubber base which forms the inside circumference, to the resilient rubber forming the wearing part of the tire. This is vulcanized to a steel rim, which in most cases is copper-plated, as the rubber compounds do not take kindly to steel. When the tire is completed, it is pressed into moulds which are securely bolted and placed in large cylindrical vulcanizers, which vulcanize or cure the rubber. When this process has been completed and the tires have cooled, slight edges remain, which are buffed off. The details of construction of the various makes differ greatly. However, Fig. 81 will serve to illustrate the general construction and its appearance on a wood wheel.

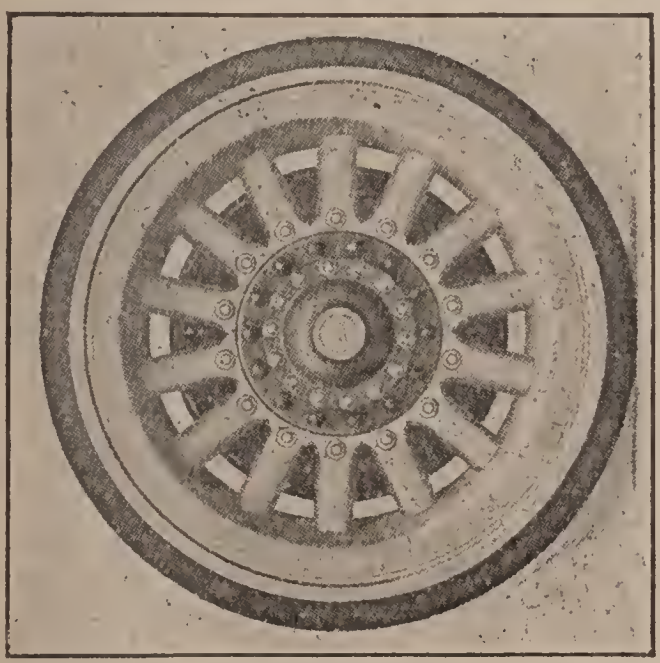

Fig. 81.—Solid tire mounted on wood wheel.

The Pneumatic Tire.

This type of tire consists of a tube made of some strong and durable fabric, generally coated with rubber, in which is enclosed another tube of thin rubber inflated with air under pressure. The

thread of the outer tube, which is known as the casing, is often provided with means designed to prevent slipping and to afford traction. When these tires were first introduced they were simply enlarged passenger car tires. It was soon found, however, that these were not sufficient, as new obstacles to tire life were discovered under new load and speed conditions, and new tire designs had to be developed. One of the problems was found in the bead of the tire. The first tires were of square woven fabric and of the straight side bead type; however, in motor truck service this tire failed by the plies pulling out from around the bead. These defects were finally overcome in changing the design of the bead so that the fabric could not work loose. Excessive heat was also generated in the body of the tire, due to internal friction in the carcass; however, the cord fabric carcass seems to have eliminated this difficulty. Fig. 82 illustrates this type of tire mounted on a wood wheel.

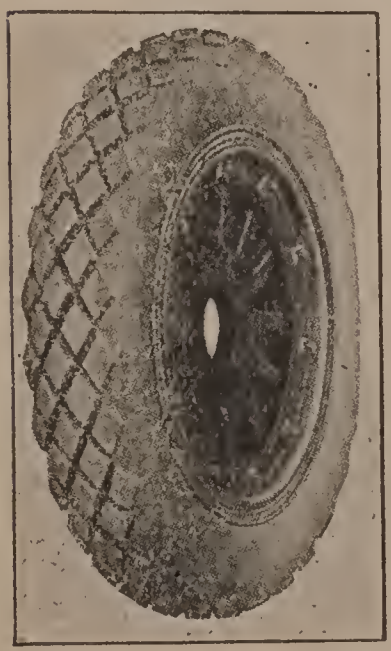

Fig. 82.—Pneumatic type of truck tire.

Proper inflation pressure is essential, and too much attention cannot be paid to this subject. Overloading must be carefully avoided. Volumes could be written on the subject of tire construction and care; however, we will endeavor to outline the underlying principles which tend to increase tire life.

Care of Tires.

The care of motor truck tires is a very important item in the maintenance of a commercial vehicle. All manufacturers of tires of either type issue instruction books, which should be carefully studied, and as tire makers are at all times endeavoring to educate users of their product, there is no reason why a truck driver should not be able to obtain maximum mileage from his tires.

There are various adjustments in the mechanical units which have been previously outlined that are essential to the life of tires. These, like all other units, have a physical limit, and results can only be obtained if their usage is within the limits of their physical strength. The most premature tire failures are due to overloading, not only by constant overloading, but by momentary overloading as well. Load distribution also has an important bearing upon the life of a tire, since poor distribution of the pay load may severely overload one tire and thus cause its destruction. Speeding has the same effect as overloading and makes every road rough, since it magnifies the minute irregularities and this increases the effect of all shocks. Poor wheel alignment, improper use of anti-skid devices, running in car tracks, and permitting oil and grease to accumulate on the rubber surface also decrease the life of the vehicle tire. Cuts in the tire should never be neglected, as they permit sand and grit to enter and eventually destroy the structure.

The above gives the general abuse of motor truck tires, and while there are numerous others of minor importance, it has been proven by maintenance engineers that tires miles can be saved by avoiding the above sources of trouble.

CHAPTER X.

Muffler and Cutout.

Their function and construction.

MOTOR TRUCKS must operate quietly and in order to avoid disagreeable engine noises mufflers are usually fitted to the chassis which are connected with the engine by means of an exhaust pipe.

Function of the Muffler.

When the exhaust valve of a motor truck engine opens at the end of the working stroke, the exhaust gases have a pressure and temperature considerably above that of the atmosphere. This pressure is estimated at forty to fifty pounds per square inch, and the temperature of the exhaust gases at 1,000 to 1,100 degrees Fahrenheit. If the exhaust gases are allowed to rush through the exhaust pipe into the atmosphere, there will be a considerable number of objectionable explosions per minute, which are very annoying to both operator and public, so that some means is generally provided to quiet these gases before they escape. This function is performed by the muffler, consequently it is the function of the muffler to so reduce the shocks of the various explosions in the exhaust pipe so as to make them inaudible or unobjectionable.

Not only must the muffler be constructed so that it will deaden the noise caused by the escape of the exhaust gases, but it must be built strong enough so as to resist the force of an explosion, which may take place in it, due to the escape of an unexploded charge from the engine. It must also

be built so that there will not be an excessive back pressure formed in it, which would lessen the power of the engine.

The pressure of the gases expanding into the atmosphere is what causes the noise, and the general theory of a muffler is to so construct it as to permit these gases to cool and expand, thereby reducing their pressure before they escape into the atmosphere.

Expansion of the gases is caused by obstructing their path through the muffler; however, in order to permit them to escape without disagreeable noise, they must be permitted to discharge very freely. If they cannot escape freely, a back pressure will be created which will act on the pistons of the engine during the exhaust stroke.

Muffler Location.

The location of the muffler in the chassis frame is generally as far away from the engine as the general design permits. Its general location is under the side rail of the frame. This scheme permits the engine to exhaust into a pipe of considerable length, the capacity of which is usually several times the piston displacement of one cylinder. The length of this pipe gives quite a chamber in which the gases have a chance to cool somewhat before they reach the muffler, while the muffler is always arranged so that heat can be rapidly extracted from the gases.

Muffler Construction.

Mufflers generally consist of a series of expansion chambers, which communicate with fine and sometimes tortuous passages. The gases are frequently baffled and their motion retarded, or they are made to flow through a series of smaller enclosures with a combined area of that of the

exhaust pipe, so as to eliminate back pressure on the engine. Mufflers are, therefore, generally made of several concentric cylindrical compartments, one within the other.

The pressure of the exhaust gases may be reduced in the muffler in one of three ways; by expansion, by cooling, and by a combination of the two. Generally speaking all mufflers reduce the pressure by expansion and cooling.

Various Types of Mufflers.

Fig. 83 illustrates the exhaust system of the sterling trucks. The muffler is supported by brackets from the frame side rail and provided with a cut-out; the function and operation of this will be explained later. The connection to the exhaust manifold is made by flexible tubing, which removes

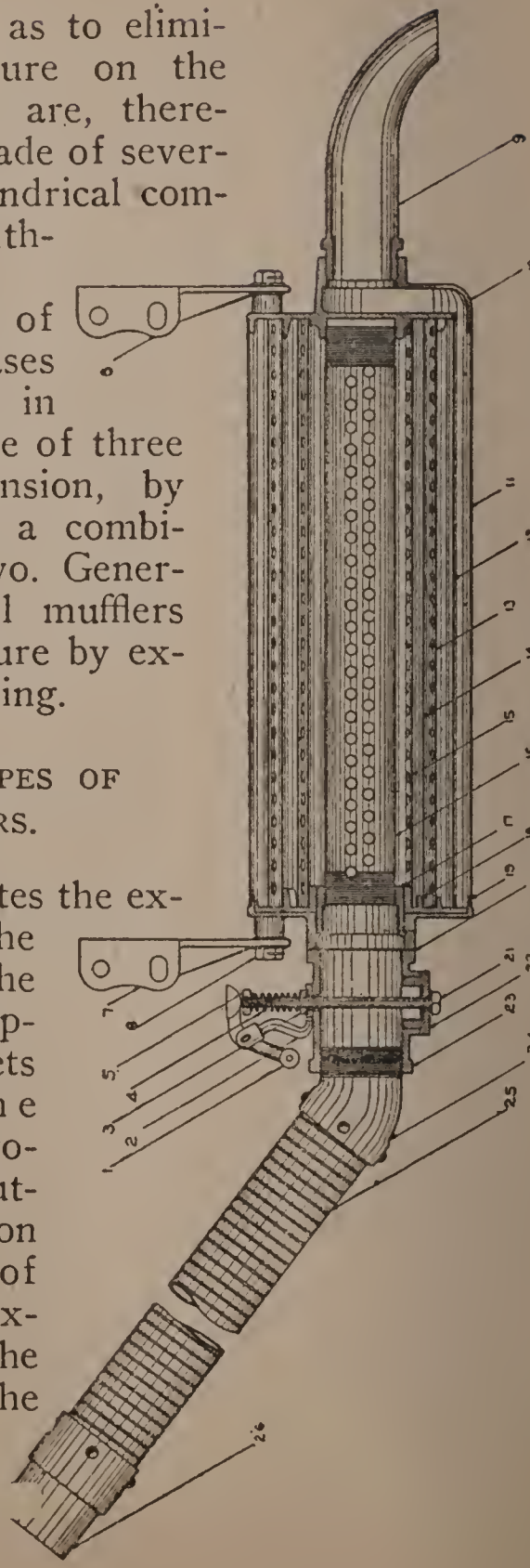

Fig. 83.—Exhaust system of the sterling truck, showing muffler, cut-out and exhaust pipe.

any possibility of frame wearing placing excessive strains upon the exhaust manifold.

The muffler used is a very popular type and consists of a series of expansion chambers formed from sheet metal tubes and cast heads which are retained by tie rods running the full length. The gases enter the inner one of the three expansion chambers through openings in the walls of the inner pipe. They expand in this chamber and then pass through fine perforations in the next chamber, and so on, thence through the tail pipe into the atmosphere. The construction of this

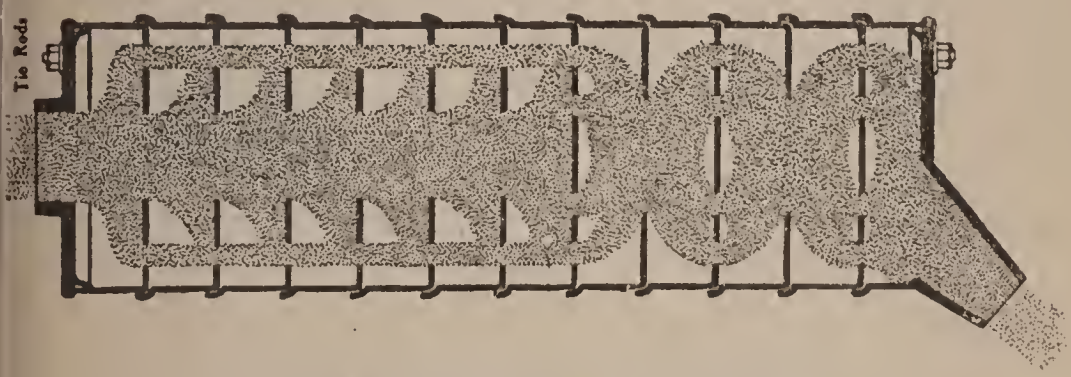

Fig. 84.—Powell pressed steel muffler.

muffler is such that it may readily be taken apart for cleaning.

The Powell muffler (Fig. 84) is also extensively used on motor trucks. This consists of a number of pressed steel cups, the open ends of which are flanged out so as to fit over the closed end of the adjacent section or cup. Each of the first series of cups have a large center opening and numerous small perforations, and through these perforations the adjacent chambers communicate. The remaining cups are so perforated as to provide a somewhat tortuous passage for the gases. The various cups, together with headers, which are malleable iron, are held together by tie rods, which permits using any num-

ber of cups to meet the requirements of each individual engine to which the muffler is fitted. The path of the gases through the muffler is clearly illustrated.

Fig. 85 illustrates a muffler which consists of several pressed steel cups and inner and outer steel shells. This muffler operates on the principle of automatic adjustment, which is that of the well-known steam ejector. Portions of the spent gases pass directly through a central tube to a high-speed jet at the outlet of that tube and induce a partial vacuum behind them, thus drawing the remaining gases through the cups in the muffler.

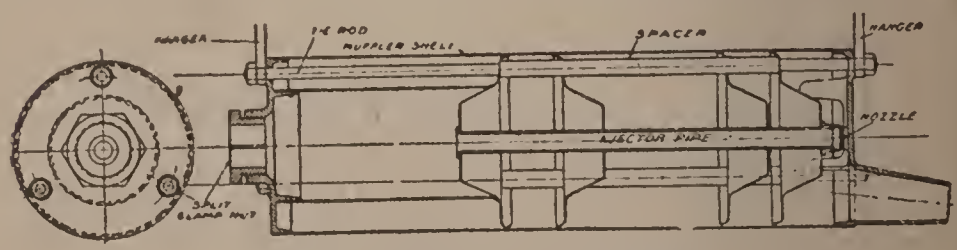

Fig. 85.—Ejector type muffler.

There are various other types of mufflers in use; however, the above will serve to illustrate and give a general idea of how a muffler operates. Aside from a construction which lends itself to rapid assembly, mufflers should possess enough strength to withstand the pressure caused by gasoline and air vapor explosions at atmospheric pressure, ability to resist vibration, and they should be so constructed as to permit cleaning. The latter would seem to be a necessity, as lubrication oils and solid carbon particles held in suspension by the gases will clog the fine passages and thereby increase the back pressure on the engine.

It is generally claimed that mufflers slightly increase the back pressure on the engine, the amount, of course, depends upon the design, while for some muffler designs the claim is made that

they actually increase the power of the engine, being so constructed as to create a vacuum by the momentum of the moving gases through it; but it is doubtful whether this advantage can be attained economically.

In order to relieve the so-called back pressure on the engine pistons, cut-outs are sometimes provided, which by-pass the gas so that it exhausts directly into the atmosphere with its attendant noise. These cut-outs may be placed either at the forward end of the muffler or in the exhaust pipe. Fig. 83 illustrates a cut-out built intregal with the muffler. These cut-outs are so constructed that they may be operated at will by depressing a foot pedal. There are three reasons why mufflers are equiped with cut-outs, to tell if the engine is functioning regularly, to clean the exhaust pipe and in some cases to have it act as a safety valve in case of explosions in the muffler.

The cut-out generally consists of a pappet or similar valve, usually held in the closed position by a spring and a suitable crank to operate it.

Care of Muffler.

The muffler is generally considered a part of the exhaust system, which begins with the exhaust manifold of the engine and includes the exhaust pipe and cut-out. It is obvious that from time to time all mufflers should be cleaned, because it will be found that they will contain a considerable amount of carbon deposits. These carbon deposits not only tend to decrease back pressure, but they retain the heat of the exhaust, so that the gases escape at a higher temperature than they otherwise would. They should be painted from time to time to prevent rusting and the bolts of the brackets and muffler parts should be kept

tight at all times. A well designed muffler should be taken apart and cleaned about once a year, and more often in case the engine should apparently lose some of its power from that cause. All carbon and burnt oil residue should be removed and all parts of the muffler should be thoroughly cleaned with kerosene before reassembling.

CHAPTER XI.

Motor Truck Governors.

Controlling the motor speed.

NO two drivers operate a truck in the same manner; some will, if they have the opportunity, speed a truck with a heavy load up to twenty-five or thirty-five miles an hour; which has been found by truck manufacturers to be above the safe margin, especially when solid tires are used, and only tends to cause premature wear.

The most practical means of obviating this seems to be by the use of a governor, which should be sealed, so that it cannot be tampered with. A properly designed governor will give a reasonably accurate regulation of motor speed, and thereby prevent excessive speeding and destruction of the truck in the hands of reckless drivers. The governor also prevents the motor from racing to a certain extent, when the clutch is disengaged, or by stopping the vehicle without stopping or shutting down the motor, assisting somewhat in obtaining economy.

There are several types of governors in use; however, the centrifugal type seems to be the most popular, while the type utilizing the speed of the gases through the intake manifold is mostly confined to the lighter vehicles. Generally an enclosed drive is provided and the governor is mounted between the intake manifold and the carburetor. There are some designs in which it is built into the camshaft gear and connected by means of rods and levers to the manifold above the carburetor. All governors in use at present

operate on the principle of regulating the quantity of mixture reaching the cylinders, but do not in any way change the quality of the mixture. The butterfly valve operated by the governor merely changes the volume of gas and allows the engine to get the proper mixture under any speed up to the setting of the governor.

Fig. 86 illustrates the Pierce governor, which is perhaps the most extensively used and supplied as regular equipment on the majority of trucks. It consists essentially of a butterfly valve located in the intake manifold, connected by a shaft to

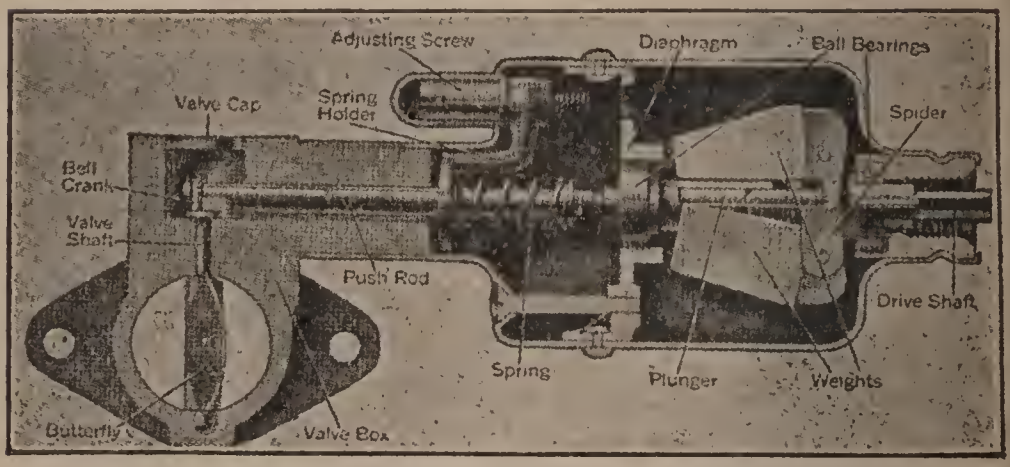

Fig. 86.—Pierce governor used on a number of trucks.

the motor and regulated on the fly ball or centrifugal principle. On the regulating shaft are two weights so pivoted that as the velocity of the shaft increases they are swung outward, forcing a plunger forward, which in turn closes the butterfly valve. The plunger is forced against a spring calibrated to a standard pressure, so that as the speed is decreased the weights return to their original position and the valve is again wide open. The operation is exceedingly simple, and an adjustment is provided to vary the setting. This adjustment is provided with a seal, so that it cannot be tampered with when once adjusted

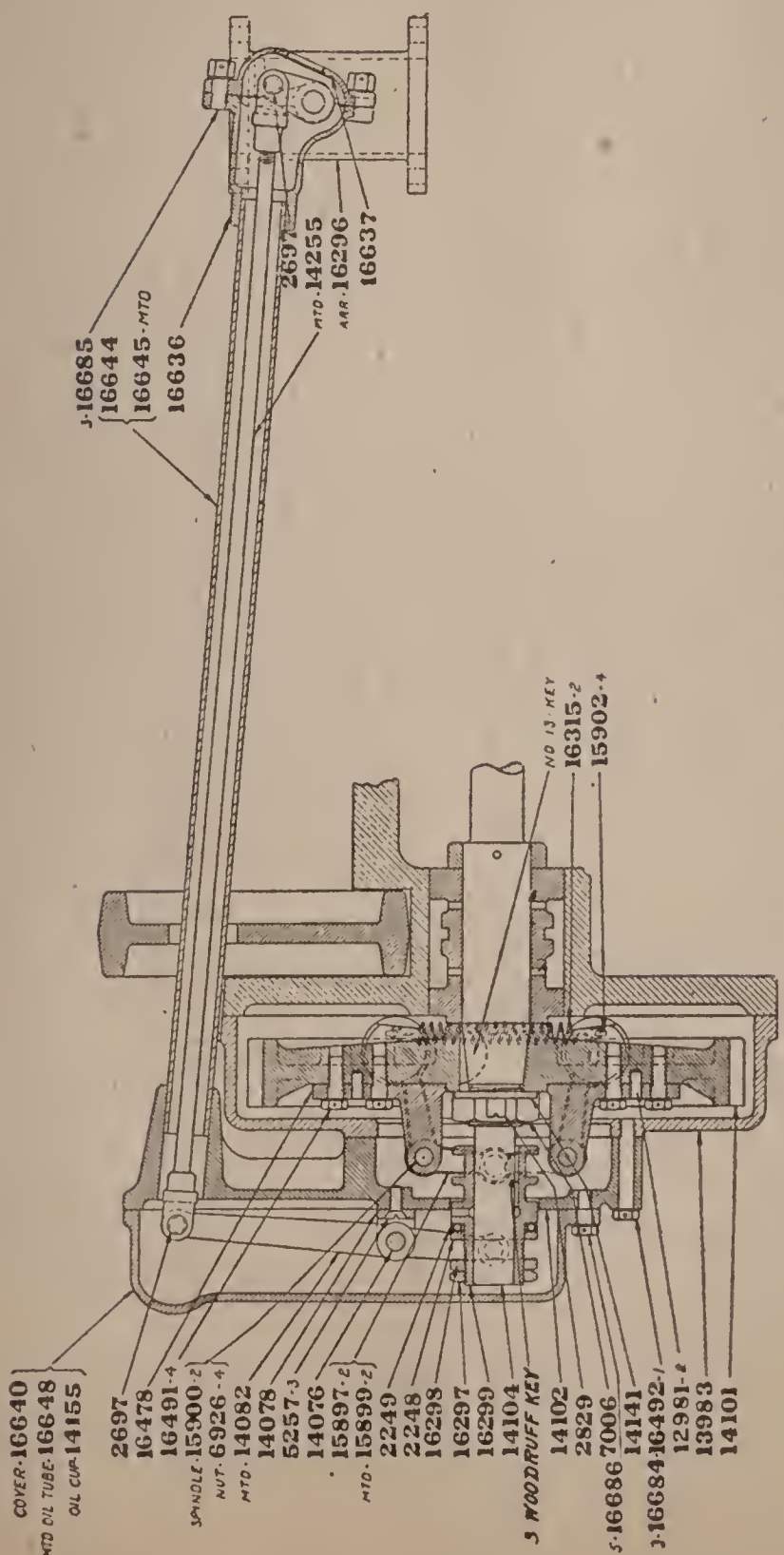

Fig. 87.—Governor mounted in camshaft gear.

to the correct speed. Turning the adjusting screw in or to the right, increases the engine speed at which the governor acts, while turning the screw to the left reduces the speed.

Fig. 87 illustrates the governor used on the Pierce trucks, which is purposely made inaccessible and mounted in the timing gear housing. The entire unit is enclosed and sealed so that it can not be tampered with, unless with malicious intent. The governor is built into the camshaft gear and operates on the centrifugal principle outlined above. There is an extension on the camshaft which supports the sliding collar to which the bell crank ends of the weights and the operating lever are attached.

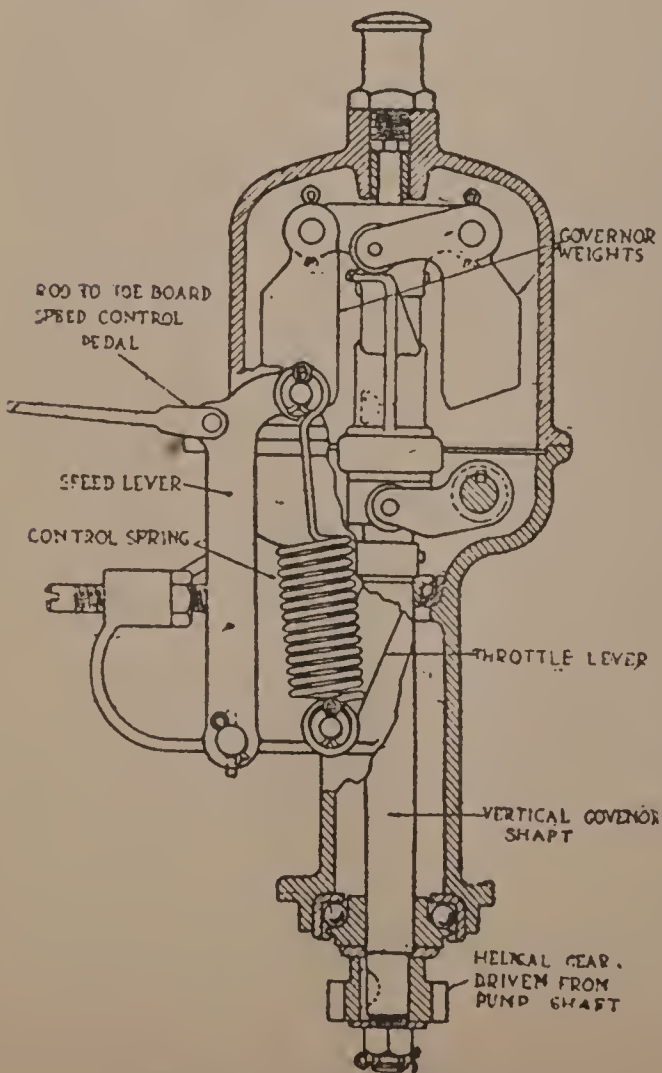

Fig. 88.—Krebs governor.

Fig. 88 illustrates the Krebs governor, which is also of the centrifugal type and similar to the above, excepting that the spark and throttle are so connected to the governor that it constantly sets them for the power, load and speed that

may be required, without regard to road conditions. The governor is also so contrived that when the clutch is disengaged, the motor continues to run at the same speed, preventing the driver from racing the engine. Engaging the clutch causes the throttle to open wide until the car reaches the speed at which the governor is set. The manufacturer claims that it takes the entire responsibility of handling the motor at all speeds and all loads.

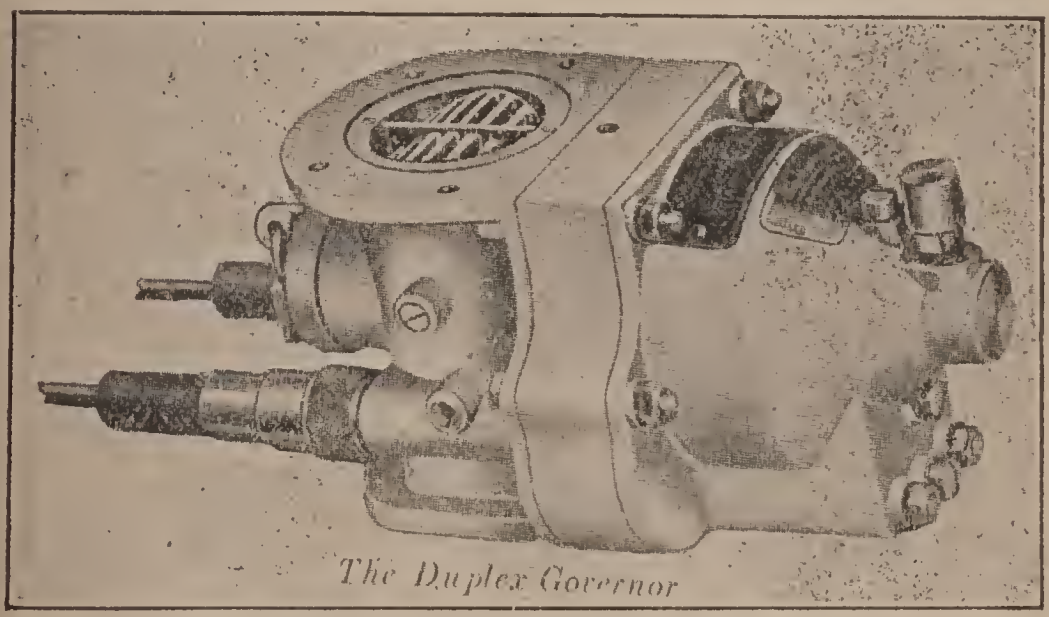

Fig. 89.—The duplex governor.

In the Duplex governor a drive is provided from both engine and transmission, and while the general principle of the centrifugal governor is retained, the drive provides a sort of dual actuating influence. This is possible, since two automatically one-way acting clutches are incorporated in the governor, the members of which consist of floating gears in mesh with a third gear mounted on the governor spindle. These clutches are so designed as to impart to the centrifugal member that of the two speeds which

is the higher. With the motor running idle, the motor speed actuates the governor and the motor is always under governor control. When the vehicle is propelled by the motor on the higher gears, the speed imparted by the vehicle will be the higher speed and will govern the motor, whereas on the low gears the motor speed will be higher and this will be the governing factor. This governor is illustrated in Fig. 89.

There is one other type of governor in use, which is known as the automatic type, and this is illustrated in Fig. 90. In this type the speed of the ingoing gases is utilized as the motive power for operating a disc which floats in the path of the gases; in other words, the speed is regulated by governing the velocity of the inflowing gases. This device consists of a throttle connected to a disc, that is allowed to float under a constant spring tension, in a tapered conduit, the tension of the spring determining the maximum engine speed. The slightest change in the velocity of the incoming gases caused by a difference in engine speed will affect the position of the disc in the conduit and also change the position of the throttle, giving the engine more or less gas as the conditions may require.

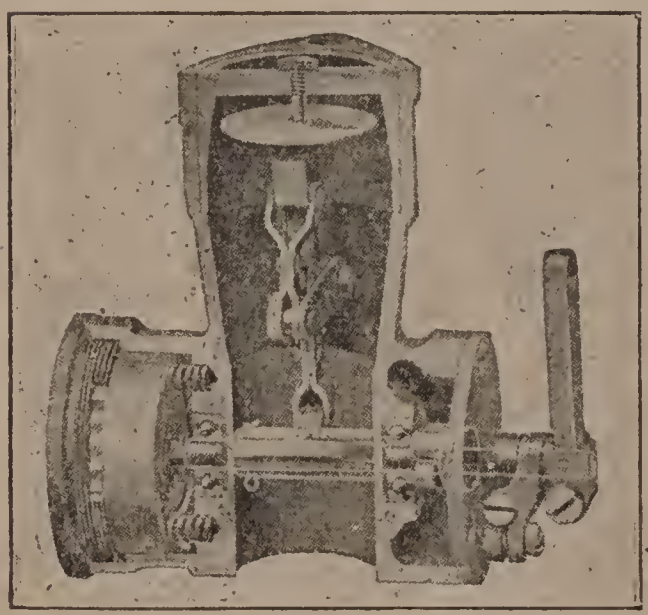

Fig. 90.—Monarch automatic governor.

There is a great difference of opinion as to the value of a governor, some cleaming that it is only a makeshift and limits the power of an engine, while others claim it is absolutely essential to prevent excessive speeding and final destruction of the vehicle. However, since it is a unit that does afford protection to the vehicle, it would appear advisable to limit the power of the engine to eliminate unnecessary repairs and excessive costs of maintenance.

The installation and care of the governor has everything to do with the service it will render, and while this part of the equipment of a vehicle requires but little attention after it is installed, it should be regularly and intelligently cared for, if it is expected to perform its duty. The proper installation is provided for in the assembling of the vehicle, and if, in service, it receives reasonable attention it will give satisfactory service. The governor, depending upon the type, will require oiling occasionally to provide the proper lubrication for its bearings and other moving parts. If for any reason the governor does not function properly, do not tamper with it, but communicate with the maker and ascertain what can be done to remedy the trouble. Owners of commercial vehicles should check the governors daily to see that the scales are intact and have not been broken and the governor setting changed. In order to make governor adjustments, consult your instruction book, and after this has been done, always replace seal.

CHAPTER XII.

Motor Truck Bodies.

Stationary and dump bodies.

THE adaptability of the power wagon to a great variety of uses in many different lines of business has called for very wide limitations in the matter of body design. In fact, the sale of commercial vehicles often depends upon the ability of the dealer to supply, either through the manufacturer of the vehicle or a body builder, a body which will meet individual requirements.

The subject of motor truck bodies is important, and an intelligent study of body design, particularly as regards the fitness of a certain type, will aid greatly in the selection of the proper body for given conditions. On this selection will depend greatly the economical operation of a motor truck. It may be that a body, designed for rear-end loading, receives the major portion of its cargoes at a loading terminus which is best adapted for a side-loading body, with the result of loss of time in loading and unloading. The motor truck earns money by transporting loads, and the axiom, "keep the truck moving," certainly applies in the selection of the body, for it can readily be understood that this has a direct effect upon the economic operation of the vehicle. Difficult loading and unloading should be solved by the use of special equipment. For instance, coal should be handled from chutes in dump bodies, likewise building material, etc. Numerous instances could be quoted to show the need

of a careful study of hauling proportions before a type of body has been decided upon.

General Construction of Bodies.

The construction of bodies should receive careful consideration from the standpoint of weight, since this directly affects the weight of the paying load which can be carried. Generally speaking, few motor truck companies build bodies, as these are usually supplied by body builders, who are principally interested in supplying a substantial body. Consequently, the general tendency is to make bodies heavier than necessary. Large companies making a specialty of building bodies give a great deal of thought to designs, from both weight and strength standpoints, while there are numerous small shops, which have grown out of former wagon building and repair shops, who are inclined to work by a rule of thumb method. Motor truck manufacturers have specified standards covering the maximum permissible body weight for the various capacities, but very often these are exceeded by the body builder, as in some cases he finds it easier to use certain material on hand rather than to reduce it to the proper proportions, to provide the proper weight of body.

The following table gives the standard body weights, which are stamped on the name-plate of each chassis:

CAPACITY.	BODY WEIGHT ALLOWANCE.
1 ton	1,000 pounds
1½ ton	1,250 pounds
2 and 2½ ton	1,500 pounds
3 and 3½ ton	2,000 pounds
4 and 4½ ton	2,000 pounds
5, 5½ and 6 ton	2,500 pounds

Bodies must be well constructed, particularly in the framing and understructure, to prevent distortion, while the effect of vibration should also receive careful consideration, as climatic conditions usually affect the timber, which dries out, and finally vibration loosens the frame joints. Some body builders have patented constructions which make all fastenings adjustable from the outside of the body.

Material.

Bodies may be made of wood or steel. The wood generally used is well-seasoned ash or oak, seams in the floor being covered with steel strips. The floor usually rests on cross-members or bolsters, which are properly attached to fore and aft sub-sills, mounted on top of the chassis frame, to which they are fastened. This forms the base for most types of bodies, the sides, etc., being arranged to suit the conditions of service. All bodies should be well ironed; that is, metal reinforcing should be used at all points of greatest wear and strain.

A body must fit the chassis for which it is intended. It should be the proper length to suit the length of the chassis frame behind the driver's seat. Body cross-members must be properly spaced to clear the wheels and other projecting parts. The sills must be high enough to provide sufficient clearance between the body floor and the tire when the vehicle is carrying its maximum load. Floor traps should also be provided. These are simply removable sections in the body floor to allow easy access to the transmission for inspection and overhauling.

Types of Bodies.

Figs. 91 and 92 illustrate a series of standard bodies, which may be termed stationary bodies.

The types illustrated are the most popular, since they meet a great variety of conditions. The platform type is the most common, as it lends itself to handling any class of material, both in bulk and packages, while by the addition of an upper structure any combination can be obtained.

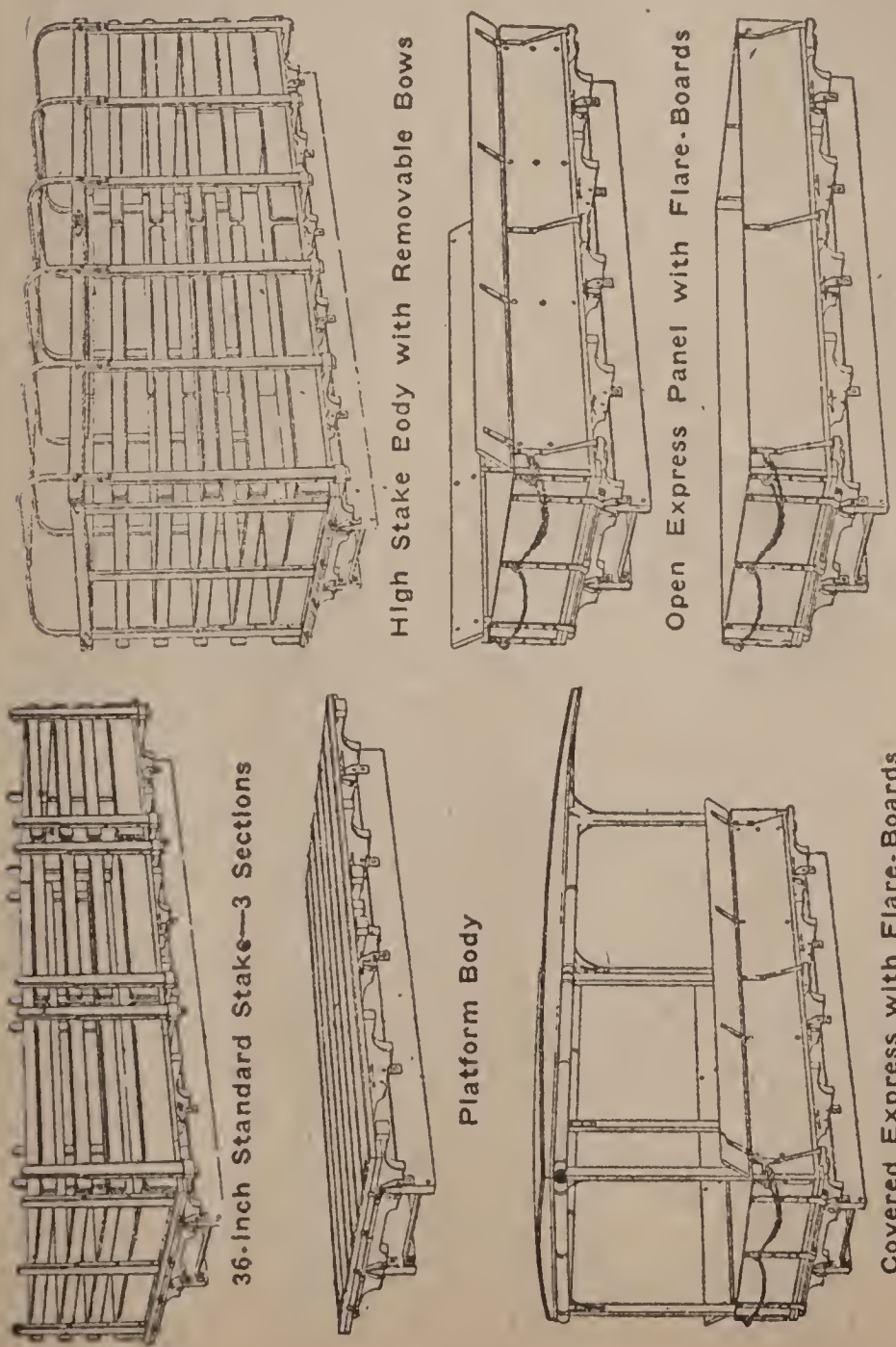
High Stake Body with Removable Bows
Open Express Panel with Flare-Boards
Open Express Panel
36-Inch Standard Stake—3 Sections
Platform Body
Covered Express with Flare-Boards

Fig. 91. Various types of standard bodies.

Dumping bodies are very extensively used in many lines of business, for hauling coal, ashes, sand, broken stone, and various other materials. This type of body is a great time saver, as it is arranged to discharge its load quickly, with little or no expenditure of human effort. These bodies are generally constructed of steel and provided with what is termed a power hoist, as illustrated in Fig. 93. This body is so arranged as to pivot over the rear end of the chassis, and the hoist is located at the other end of the body.

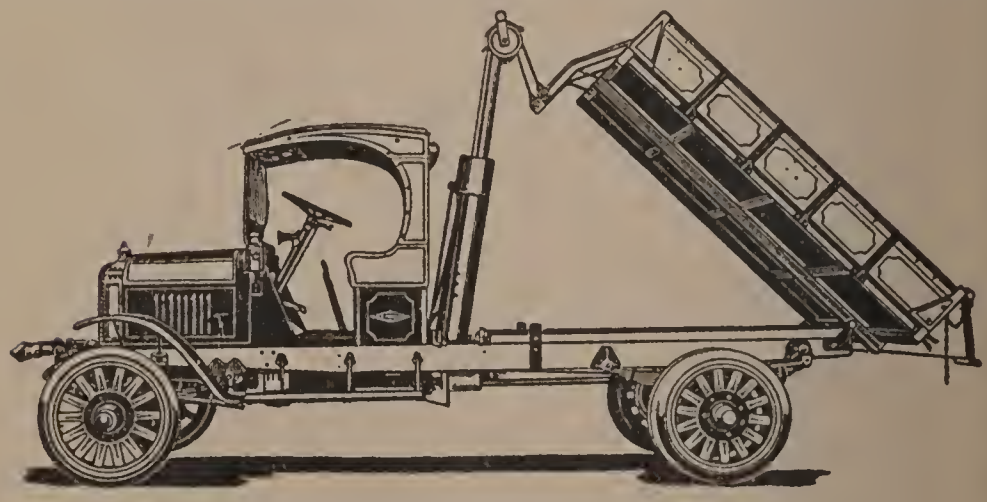

Fig. 93.—Dump body with power hoist.

Power to operate the hoist is obtained through a power take-off mounted on the transmission. The hoist permits tilting the body about 45 degrees. This hoist is made in two types, the vertical and horizontal type, and both are extensively used. Hand-operated or gravity dump bodies may also be had for capacities from 1 to 2½ tons.

Demountable Bodies.

For certain classes of work, the demountable body is well adapted; this is particularly true in relay work. These bodies are so constructed that they can be quickly transferred from one

chassis to another. The complete installation will, of course, include the necessary means for handling the bodies on and off the truck chassis. This type of body has one desirable feature, in that the running time of the vehicle is increased, as it is not required to stand idle while material to be transported is being loaded into or from the body. The ideal demountable installation generally consists of three bodies for one chassis; one body being loaded, another unloaded, while the third one is in transit on the truck. Under these conditions the vehicle is working most efficiently; however, the first cost of the installation is considerable and the conditions of service must warrant its use.

Special Bodies.

Considering the motor truck chassis as simply a foundation or mobile platform, it is apparent that almost an endless variety of structures may be mounted upon it. This offers a broad field, affording opportunities for the design of highly specialized equipment. Many interesting and practical installations are in service. Many motor truck companies have installed a transportation engineering department, which if called upon will design special equipment of this type and render advice on any hauling problem. Users and prospective users of commercial vehicles should avail themselves of this service if highly specialized equipment is desirable.

Driver's Cab.

In order to provide protection for the driver against climatic conditions, most all truck makers now include as regular equipment some form of driver's cab instead of an open seat, which was the custom in the past. Constructions vary in

detail, but they are generally of the all-weather type, illustrated in Fig. 94, which is provided with a windshield and windows which disappear in the walls of the cab. Storm curtains are gen-

Fig. 94.—Drivers' all-weather cab.

erally used to enclose the remaining portion of the cab, although the one shown is provided with doors.

The above gives a general idea of motor truck bodies, and while considerable may be written on the subject, it is suggested that haulage problems be thoroughly analyzed before the vehicle capacity and type of body are decided upon, as the conditions of operation and the nature of the materials to be transported have an important bearing upon economical operation.

H 154 81

MAY 81

N. MANCHESTER,
INDIANA 46962

LIBRARY OF CONGRESS
0 013 509 983 1